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AUTOMATION OF TROOP CONTROL

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This report contains information on the prerequisites and scientific bases of automation; troop control and command in combat as an object of automation; the possibilities of development and the real state of automation; methods of automating troop command; the role of the human soldier in ASUV [automated system of troop command and control]; the effect of automation on the development of military affairs, the styles and methods of troop leadership.

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[Brief Annotation]

[Text] The book examines the following pertinent methodological questions: The prerequisites and scientific bases of automation; troop control and command in combat as an object of automation; the possibilities of development and the real state of automation; methods of automating troop command; the role of the human soldier in ASUV [automated system of troop command and control]; the effect of automation on the development of military affairs, the styles and methods of troop leadership.

These problems are examined on the basis of Marxist-Leninist methodology using materials from research in cybernetics, mathematics, psychology and military science, using foreign and hypothetical ASUV as the examples.

The book is designed for officers, generals and other readers interested in the problems of automating troop command.

[Author Collective]

The book has been prepared by a group of authors consisting of: Doctor of Military Sciences, Engr-Maj Gen I. I. Anureyev (Section 2 of Chapter 3); Doctor of Philosophical Sciences, Engr-Col V. A. Bokarev [posthumous] (Section 3 of Chapter 1); Candidate of Philosophical Sciences, Col V. M. Bondarenko (Sections 1 and 2 of Chapter 1 and the Conclusion); Candidate of Philosophical Sciences, Engr-Col A. F. Volkov (Section 3 of Chapter 3, Sections 2 and 3 of Chapter 4, and the Introduction); Candidate of Military Sciences, Maj Gen P. V. Grabovskiy (Section 1 of Chapter 3 and Section 2 of Chapter 6); Doctor of Philosophical Sciences, Col A. P. Dmitriyev (Chapter 2 and Section 1 of Chapter 4); Doctor of Military Sciences, Col N. A. Zubkov (Sections 1 and 3 of Chapter 6); Candidate of Philosophical Sciences, Engr-Lt Col A. B. Pupko (Section 1 of Chapter 5); Doctor of Philosophical Sciences, Col N. D. Tabunov (Section 2 of Chapter 5); Candidate of Military Sciences, P. V. Shemanskiy (Chapter 2); Doctor of Philosophical Sciences, Maj Gen M. I. Yasyukov (Section 3 of Chapter 5).

The book is under the general editorship of Candidate of Philosophical Sciences, Col V. M. Bondarenko and Candidate of Philosophical Sciences, Engr-Col A. F. Volkov.

INTRODUCTION

The creation of a modern and most rational system for organizing and controlling all spheres of life in a socialist society occupies a prominent place in the activities of the CPSU. In its practical work the CPSU is guided by the Leninist requirements of scientificness of control, the ability to correctly determine the prospects and sequence of the tasks to be carried out, orientation toward the newest scientific and technical achievements, advanced experience, flexibility, and the ability to respond quickly and precisely to changing conditions. V. I. Lenin repeatedly stressed that it is impossible to manage effectively without a knowledge of the science of management. He steadfastly demanded that the administrative and scientific aspects be combined in management.

"...In order to manage," he wrote, "it is essential to be competent, it is essential to know all the production conditions completely and down to the fine points, it is essential to know the equipment of this production at its present-day level, and it is essential to have a certain scientific education."[1]

The Leninist methodology of scientific management has been reflected in the party documents and in the decisions of the congresses and plenums of the CPSU Central Committee. "The dynamic nature of the development of Soviet society," commented L. I. Brezhnev at the 25th Party Congress, "the growing scale of communist construction and our activities on the international scene urgently require a continuous rise in the level of party leadership over economic and cultural development, over the indoctrination of people, as well as an improvement in the organizational and political work in the masses."[2] The task posed by the 25th Party Congress of further improving the scientific level of management applies fully to military affairs. Leadership over the defense of the socialist fatherland is most closely tied to a range of problems related to economic development, to strengthening the sociopolitical system, and to raising the ideological-political and cultural-technical level of the working masses. The Soviet Armed Forces, has an integrated, complicated and dynamic system, are a part of the socialist state. Consequently, the provisions elaborated by the party on the scientific management of socialist society relate directly and immediately to the sphere of troop command and control.

The question of elaborating and using optimum methods and means of troop control has always been and remains one of the basic questions of military science. The experience of the Great Patriotic War, all military history as well as present-day military science and practice indicate that a loss or weakening of control can become the cause of failures and defeats. The revolution in military affairs has placed new, higher demands upon the efficiency and effectiveness of control, and consequently, also on the level of operational and tactical thinking, and on the ideological-political, moral-psychological and volitional qualities of the commanders and officers of the command level.

As the theory and practice of control have shown, the integrated automation of the control process is the most promising, making it possible to bring the system of troop control into accord with those requirements which have been placed on it by the increased combat capabilities of all the branches of forces and services of the armed forces. Under the conditions of a modern war, if the imperialists start it, the task of mastering the scientific methods of troop command on a basis of new technical means assumes exceptional urgency. Troop command should be improved in keeping with the achievements of scientific and technical progress. Military science must in every way contribute to improving control equipment and the communications system, and should aid in further introducing computers and other automation in the staffs and their skillful use.

Consequently, the realization of the combat capabilities of the troops depends substantially upon effectiveness and efficiency of control, and automation is the most effective means for improving this.

The process of working out and introducing various automation facilities into the practice of troop control at present is entering a qualitatively new phase of its development, the stage of full automation of control. In this stage, "large systems" are being developed and these include human collectives, automatic control complexes and servomechanisms which have a hierarchical structure that encompasses all levels of the military organization from the primary troop collectives to the superior command of the armed forces.

Naturally, the creation of such systems entails the achieving of a certain level of economic, scientific-technical and certainly military potential, and necessitates the solving of a whole series of theoretical and technical questions. Along with this the methodological problems of the automation of control are assuming ever greater, and in certain regards, determining significance.

In the age of the rapid development of science, the elaboration of the philosophical problems of modern natural science on the basis of dialectical materialism, as a consistently scientific method of cognition, is assuming ever greater urgency. The solving of methodological problems is assuming particular urgency in a period of qualitative changes, dialectical leaps and transitional stages in the development of science and

technology. Automating troop command and the entire complex of related scientific and technical problems are also subject to such stages.

Methodological analysis of the possibilities, ways and goals of automating troop command should consider social factors. Certainly a person on any level of ASUV [automated system of troop command and control] acts as a social being. Inherent to him are creative thought, class awareness, national feelings, emotional experiences, intuition, as well as economic, political and ideological motives of activity.

If in automating the control systems for weapons, tactical units and military equipment, it is possible to partially disregard the social essence of man, in automating troop control systems in which man is a most important object and the main subject of control, it is virtually impossible to do this.

Methodological analysis makes it possible to isolate and pose for the specific sciences the most important and urgent problems, to establish the general conditions for solving them, and to outline the direction of the corresponding research. It helps answer the questions of the essence, the degree of possibility and the aim of automating troop control. The given work is devoted to a scientific analysis of all these problems. It examines the basic general theoretical provisions stemming from the dialectical materialistic notion of the laws of nature, society and thought, the Marxist-Leninist understanding of the patterns of scientific and technical progress and armed struggle and determining the necessity, possibility and direction of automating troop control.

Since the problem of automating control has an interdisciplinary nature, the research on this problem requires a systems approach. Proceeding from this the authors have set for themselves the task of examining as thoroughly as possible the methodological problems of automating troop control. The book employs the achievements of Soviet military, military engineering and military philosophical thought.

In working on the book, the authors have been guided by the requirements of the CPSU Central Committee, the Soviet government and the USSR Minister of Defense for improving the principles of scientific control, employing progressive methods of control, and introducing electronic computers and automated systems.

FOOTNOTES

1. Lenin, V. I., "Poln. Sobr. Soch." [Complete Collected Works], Vol 40, p 215.
2. "Materialy XXV S"yezda KPSS" [Materials of the 25th CPSU Congress], Moscow, 1976, p 65.

CHAPTER 1: THE OBJECTIVE NECESSITY AND SCIENTIFIC BASES OF AUTOMATING TROOP CONTROL

1. Automation as a Natural Stage in Developing Systems of the "Man--Equipment" Type

The full automation of control is an offspring of our times, the second half of the 20th century. It was engendered by the present-day scientific and technical revolution, and at the same time expresses its essence. Any process or phenomenon in social life experiences the impact of the scientific and technical revolution. It opens up for mankind new horizons in understanding the secrets of nature and in a profound comprehension of the objective patterns of social development.

Each phenomenon possesses an essence which determines its further development. Research on the essence of the present-day scientific and technical revolution is an important and complicated theoretical problem, the solution to which is possible only on a basis of applying the methodological principle elaborated by K. Marx and F. Engels in analyzing the industrial revolution at the end of the 18th and the beginning of the 19th centuries.

The founders of Marxism showed that the development of production, like any other sphere of social activity, is based upon an improvement of the system which links man as the principal of any type of activity and the technical means. It is a question of a system of the "man--equipment" type which is a united mechanism of labor. In it the equipment is simultaneously a certain antipode of man and his continuation. In the opinion of K. Marx, equipment represents the artificial organs of a social man and these complement and strengthen his natural organs.[1] Such an analogy provides an opportunity to view the history of the development of technology not in isolation from man, but rather as an improvement of his artificial organs.

The development of technology represents the process of the creation by man of those devices which in an ever greater volume perform man's own functions. The production process can be represented in the form of a definite relationship of live and embodied labor. The former is carried out directly by the principal [man] with the aid of its natural organs. Being in

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origin also human, the second type of labor is performed by people using the technical means which they have created. While live labor can be termed directly human, the embodied labor is the mediated and previous labor of man. Live labor is the basis of embodied labor.

The volume of embodied labor is increased by reducing the volume of live labor. The replacing of human strength by the forces of nature, the gradual broadening of the volume of embodied labor and the replacing of live, directly human labor by it comprise the basic principle in the inner development logic of systems of the "man--equipment" type. "There is nothing 'incongruous' in the replacing of manual labor by machine labor; on the contrary, all progressive work of human technology consists in this,"[2] wrote V. I. Lenin.

Externally the impression may be formed that man is being squeezed out of diverse areas of activity, including from the sphere of armed combat. However, the term "squeezing out" is still applicable. V. I. Lenin wrote: "The higher technology develops, the more the manual labor of man is squeezed out, in being replaced by a series of ever more complicated machines...."[3] V. I. Lenin emphasized that not man is being eliminated but rather the manual, routine, machine-like and unproductive labor. Consequently, it is not a question of expelling man or not an antagonistic competition between man and technology, but rather a constant redistribution of functions between them. In turning over unproductive operations to equipment, man gains an opportunity to concentrate his activities on the performance of more complicated duties which require the mobilizing of all his creative possibilities. Expanding the volume of embodied labor in all spheres of human activity significantly increases the productivity of live labor and the efficiency of all production.

The change in the volume of live and embodied labor does not occur spontaneously, but rather in a definite direction. Here the qualitative shifts in the "man--equipment" system occur in the creation of a technical device which helps man more effectively perform one of his basic functions in the production process or activity. Such basic functions are: The function of a source of energy, an engine, a transfer mechanism, and a direct effect on the subject of labor and control. In terms of the nature of execution, all of these differ from one another. The functions of the direct processing of the subject of labor and control require from man a definite mastery, skill and ability. The remainder are based upon simple physical strength.

At the end of the 18th and the beginning of the 19th centuries, only the functions of the direct processing of the subject of labor and control were carried out by man, while the others had been taken over by equipment. For this reason, there was the valid assertion by K. Marx that "the industrial revolution starts by the use of a mechaism where man due to the very nature of things does not act from the very outset merely as a simple strength."[4] In the first industrial revolution, this was a function of

the direct processing of the subject of labor. The working machine replaced the human hand armed with a simple tool. Precisely this led to the transition from artisan production to machine production. Any type of machine consisted of three elements: The engine, the transmission mechanism and the labor force.[5]

The qualitative changes in the "man--equipment" system could not occur in and of themselves, in isolation from the socioeconomic conditions. Thus, the rise of machine production led to the necessity of breaking up the socioeconomic relations of feudalism and to the establishing of the new, capitalist socioeconomic formation.

The next step in improving systems of the "man--equipment" type was in the technologizing or the materializing of the control function. In our times there has been a transition from the machine as the technical basis of production to the automaton. The control device becomes the fourth component of the machine which is now turned into an automaton.

The creation of automatic machine tools and automatic lines is only the starting point for the automation of production. Along with the development of automatic production cells (machine tools, lines, plants, and in the future, groups of plants), the automation of production is also expressed in the rise of automated systems for the accounting and control of production. Such systems make it possible to automate the process of the collection, transmission, and storage of production information, as well as its processing according to a preprepared program. Being a historically determined phenomenon, automation develops gradually, on the basis of the existing production equipment and methods. The introduction of automated equipment leads to the necessity of transforming the production equipment and methods.

At present automated systems for collecting and processing information for accounting, planning and management have gained great development. They encompass the work of not only the individual enterprises, but also entire industrial complexes and even production sectors. In the nation there are around three automated systems for the management of enterprises and organizations in industry, agriculture, communications, transport and trade. On the basis of a planned socialist economy, a fundamental opportunity appears of creating a statewide automated system for collecting and processing data related to accounting, planning and managing the national economy. The essence of the present-day scientific and technical revolution is directly linked with the automation of production, and with the transition from machine production to fully automated. Automation, on the one hand, is an indicator of the successes of science and technology, and on the other, the most promising area for the application of their achievements.

An analysis of the development of production systems of the "man--equipment" type indicates that automation is a natural and historically necessary stage of their improvement. The given trend is also inherent to such a specific class of systems as "man--military equipment." The similarity

between the production and military activities of man is obvious. On this issue K. Marx at one time wrote: "War reached developed forms previously than peace; a method by which in war and armies and so forth certain economic relationships as hired labor the use of machines and so forth developed before than within civil society. Also the relationship between the productive forces and the relationships of intercourse is particularly apparent in the army."[6]

The designated similarity, in particular, derives from the biological specific features of man and his physical and mental capabilities. Initially human production activity was simultaneously a struggle for existence. Thus, even the hunting of wild animals by its nature in virtually no way differed from the armed clashes between tribes. Only in the course of historical development did the fundamental opposition between the purpose of an army and production make a specific imprint on the functions performed by man in combat.

At the same time this did not violate the general pattern inherent to all classes of systems of the "man--equipment" type.

The functions performed by man in the process of combat can be classified in two groups. Those which are related to great energy expenditures comprise the first group. These include the functions of the source of energy, the engine, the direct defeat of the enemy, the delivery of the weapon to the target, and so forth. The second group is made up of control functions. Although they also require certain energy expenditures for carrying them out, they are based on the use of human mental features which determine the possibility of processing information and controlling the troops.

Since the physical capabilities of man are immeasurably more limited than the mental ones, the process of materialization or objectification started precisely with them, and above all with the increase in the energy capacity of the "man--military equipment" system. For a long time animals (horses, elephants, camels and so forth) were used for these purposes. Then steam power began to be used in military affairs and this led to a qualitative transformation of the navy, the development of a steam metal-hulled fleet. The use of internal combustion engines led to the motorization of all services of the armed forces, and altered the nature of military labor (its technology). The appearance of electric power and its extensive use in all areas of military affairs were of enormous significance. While the energy base determines the nature and level of development of the weaponry, it becomes the decisive force in the development of military affairs, although in principle other weapons can be used, for example chemical and bacteriological weapons against the enemy. The imperialist states are presently developing such weapons, and for this reason the threat of their use cannot be considered completely eliminated. However, the history of wars does not know the broad use of these weapons. For this reason it is important to focus attention on the inner development logic of military affairs under the conditions of using energy-based weapons.

The energy capabilities available to an army and navy also determine the development of the delivery systems which have undergone a historic path of development from the bow to modern missiles. The important turning points on this path were the appearance of rifled weapons, artillery, tanks and aviation.

The objectification in equipment of those functions of the activities of a soldier on a battlefield which are based on large expenditures of physical energy is termed mechanization. Its first stage can be termed partial mechanization. This involved only individual operations, while a larger portion was carried out by human muscle power. At this stage even the servicing of the equipment required great physical strength and endurance from a person. Here the soldier performed only narrow, special operations. Mechanization in the armed forces remained partial right up to the end of World War II.

Gradually partial mechanization developed into full. Mechanisms replaced human muscle power not in individual operations but in the complete cycle of the combat activities of the soldier or troop collective. To a significant degree full mechanization reduced the outlays of human muscle power, and in a number of areas reduced human activity to a series of monotonous and fatiguing operations.

Full mechanization is closely linked to the process of the automation of control. In literature, automation is sometimes understood as the general process of objectification in technology of human functions in various spheres of social activity. In this instance the concept of automation, in essence, is considered identical with technical progress generally. The rise of firearms, the motorization of an army and other important stages in the development of military affairs, proceeding from such an understanding, can be represented in the form of the early stages of automation. In this instance, mechanization operates as the initial period of automation, and at the same time embodies its qualitative change and complication. We feel that such an approach is incorrect, for in this concept two processes which differ in their quality--mechanization and automation--are arbitrarily considered identical.

A specific feature of automation is the transferring of the functions of data processing and control to special controlling technical systems. The possibilities of automation have existed in all stages of the development of technology. However the process of automation, and particularly full automation, actually began with the rise of electronic computers, and with the possibility of not only transmitting and storing but also processing the information. On this level, automation is a completely definite historical stage in the development of production and any other equipment. It embodies the present-day scientific and technical revolution.

Hence, automation (in contrast to mechanization) represents a process of objectification or materialization of control functions in technical devices.

The controlling technical devices and systems replace man in the control processes and thereby improve the efficiency of human activity. Automation crowns present-day technical progress and represents its apex in our times. In terms of troop control, automation is the process of creating and introducing into staff work the electronic computer and various related highly productive technical devices with the corresponding softwear for the purpose of raising the combat readiness of the troops and the efficiency of their control.[7]

In differentiating mechanization and automation, one must see their close relationship. On the one hand, mechanization becomes more effective, it develops in breadth and depth and approaches its completion only in a period of developed automation of troop control. On the other hand, automation could arise and gain extensive development only on a basis of the sufficiently developed mechanization of the troop labor processes.

The qualitative transformations in the "man--military equipment" system do not occur in isolation from the other aspects of military affairs. They are linked to its general development in the entire complexity of its sociopolitical, military-technical and specifically military aspects. Revolutions in military affairs can occur both on the basis of fundamental changes in equipment (weapons) as well as on the basis of fundamental changes in the social quality of a war. For example, revolutionary changes in military affairs on a level of the qualitative changes in human material were characteristic for the period of the Napoleonic wars. They became possible due to the emancipation of man and to the appearance of the free French citizen.[8]

Although the present-day revolution in military affairs is based upon a fundamental transformation of the military technical base, it does not end with this. The fundamental changes in weapons of necessity lead to a change in all other areas of military affairs. The inevitability of such a process was profoundly elucidated by F. Engels in the example of analyzing the revolution in military affairs related to the appearance of firearms. The mechanism of the present-day revolution in military affairs is also based on fundamental changes in the weapons system which consists of three basic components (see Figure 1).

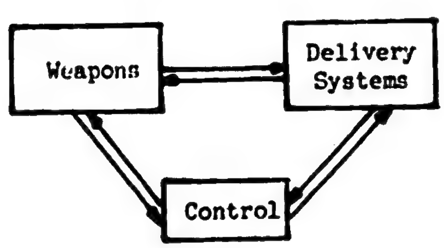

Fig. 1

The present-day revolution in military affairs (or the military technical revolution as its technical base and material foundation) began with the fundamental transformation of weapons, that is, with the appearance of nuclear weapons. Such a start is completely natural, for the development of weapons determines the level of efficiency in the entire "man--combat weapons" system. In terms of the type of energy used to defeat the enemy, history knows three weapons systems: cold steel, firearms and nuclear. In the first, a mechanical blow of a sword, spear or arrow was used for causing defeat; in the second, an explosion of conventional explosives; in the third, a nuclear explosion. In nuclear weapons there has been an increase in the number of destructive factors. These are the shockwave, the thermal and light radiation, penetrating radiation and the radio active contamination of the terrain. Nuclear weapons have significantly broadened the destructive possibilities of the modern armed forces.

The qualitative change in weaponry has upset the established equilibrium between the elements of the weapons system.

In this regard a lag was discovered in the delivery systems and this was eliminated only after the creation of a developed system of various types of missiles. The combining of the enormous fire power of nuclear weapons with the missile delivery systems comprised the system of nuclear missile weapons. Its appearance disclosed the insufficiency of the traditional methods and means of troop control. The need arose of a qualitative change in the control of troop combat as well.

Thus, the present-day revolution in military affairs is undergoing three basic logical stages of its development.

The appearance of nuclear weapons and their fundamentally new capabilities and new destructive properties have forced a revision in the reviews on the conduct of combat.

There arose such a fundamentally new method of conducting combat as the nuclear missile strike. The tactical and operational views on the conduct of combat continued to be improved. The demands were increased on the maneuverability of the formations and units and the views were altered on the offensive and defensive. The balance between tactical, operational and strategic operations was fundamentally altered. The nuclear missile weapons, in essence, became the first means of strategic action. They make it possible to achieve strategic success directly, and create favorable conditions for the other types of forces to develop this success.

The introduction of nuclear missile weapons in the troops led to a change of their organizational structure. A new service of the armed forces arose, the Strategic Missile Troops. Nuclear weapons also appeared as part of the other services of the armed forces. Missile subunits became component elements in the motorized rifle formations.

New demands were also made on man. Under the conditions of nuclear missile warfare, surprise acquired particularly important significance. The strengthening of the combat readiness of the troops and greater responsibility for each serviceman for carrying out his duty became a command of the times. Military activities became more intensive and taut. In their nature they approached industrial labor. The intellectual level of military labor rose and the number of military professions increased.

The development of nuclear missile weapons brought about a fundamental reorganization in troop command. The enormous speed of the missiles, the extreme fluidity of combat under the conditions of modern combat, the increase in the amount of information, the complicating of the methods of transmitting it, the reduction in the data processing time, and the sharp increase in the demands made upon the soundness of the decision being taken--all of this forced a revision in the traditional system of troop control. The capabilities of man as the controlling link in the "man--military equipment" system began to impede the development of the entire system, and thereby military affairs. The way out could be found only in a qualitative improvement in the process of controlling troop actions. The development of automated control devices became the technical basis for such a transformation. There was a new redistribution of functions between the human and the technical components within the unified "man--military equipment" system. Automation solved the most important problems in the development of military affairs.

Being a necessary element in the inner logic of developing the "man--military equipment" system, automation is a natural stage in the improvement of the latter. The given notion is valid only by considering two circumstances as well.

In the first place, it is essential to abandon the rigid correlation which supposedly exists between automation and the nuclear missile weapon. Certainly the broadening of the scale of armed combat, the greater fluidity of combat, the increase in the number of factors which must be considered in decision taking, the decisiveness of the goals and missions of troop combat stemming from the irreconcilability of the socioeconomic and class contradictions resolved in modern wars--all these factors during the years of World War II showed the lag of traditional command and control and required a fundamental revision of this. The appearance of nuclear missile weapons disclosed the fundamental unsuitability of the old means and methods of controlling troop combat under the conditions of modern warfare. At the same time, these weapons arose because the possibility of automating their control had become a reality.

Secondly, the inner development logic of systems of the "man--military equipment" type is realized under specific historical conditions on the basis of a definite centuries-long evolution of the very process of troop control.

2. Automation as an Expression of the Historical Development of Troop Control

During the first stages of the existence of the armed forces, control was dispersed among the other functions of people in armed combat. The commander or military leader not only directed combat, but also himself took an active and required part in it. During the period of a slave owning system and in the early stages of the feudal system, the fate of an engagement was determined on a small area (just several kilometers along the front), and by relatively small armies which were homogeneous in their composition. The military leader had a complete view of the battlefield and he gave commands by voice or by signals. Under these conditions there was no need for a complex system of troop command.

The further development of military affairs led to a complicating of the processes of controlling the troop combat. First of all with the rise of the absolutist monarchies the size of armies increased. They began to number in the hundreds of thousands. All of this led to the necessity of having a more diversified structure of the armed forces consisting of armies, corps, divisions and tactical units. The complicating of the organizational structure presupposes the assigning of independent missions to each of the elements of the combat organization, the development of a definite hierarchy, and the establishing of the levels of centralization, the rules and standards of subordination between them, and so forth.

The complicating of control was also caused by the significant development of the military equipment and weapons. The appearance of firearms and subsequently the artillery sharply increased the combat capabilities of the troops, it broadened the zone of combat, and raised the importance of camouflage and field works for the troop battle formation. The involvement of new weapons increased the number of factors which would determine the course and outcome of combat. In taking a decision for combat, the commander of any level should now specially think through the methods of using firearms, and particularly the artillery. In this regard the function of control became separate and was turned into an independent process of combat activity. The military leaders of all ranks were released from direct participation in combat. Their functions now came down to troop control or command, and this accelerated the process of improving the control system.

However, under such conditions a person would find it impossible to handle the entire volume of control activities. Gradually a group of persons grew up around the military leader and they helped him carry out control. Initially their task was merely to transmit the orders of the military leader to subordinate commanders. In essence they were liaison. In time their duties grew more complex. As advisers they began taking part in working out the dispositions for combat, to draw up the required documents, and carried out the preliminary processing of information received from the troops. They were granted rather extensive powers to organize combat on the spot where they arrived with orders from the commander, and so forth.

The broadening of the amount of work and the complicating of missions in troop command led to the rise of a specialized command body, the staff, which at first performed a strictly auxiliary role in the command process. Even in the army of Napoleon, the role of the staff was secondary. The chief of staff, Marshal Berthier, for example, was virtually without any rights. His duties came down basically to the writing out of the orders of the emperor.

The passive role of the staffs was determined by objective and subjective factors. The former were explained by the relative simplicity of command as the commander could independently solve all the basic questions. But the subjective factors consisted in a certain lack of confidence in the staff on the part of the military leader. Moreover staff work was considered secondary and not having sufficient moral prestige.

The establishing of the staff as a fully empowered body of the commander for troop command was caused by new changes in the armed forces. At the start of the 20th century a rapid process of greater complexity of weaponry in the army and navy commenced, and all the services and branches of arms were motorized. The appearance of aviation, tanks, an armored naval fleet and the motorization of the infantry not only changed the appearance of the armed forces but also sharply expanded the limits of their combat capabilities. In spatial terms not only the surface of the land and the sea but also the air ocean became the sphere of armed combat. The motorization of the army and navy altered the nature of combat which became more fluid and mobile. While World War I had a clearly expressed positional nature (firing in it clearly predominated over movement), in World War II maneuvering predominated. Troop command assumed a continuous nature.

The scale of combat and the size of the armies also grew significantly. The armed forces became multimillion. There was a sharp change in the qualitative composition of the army and navy which were also no longer a homogeneous aggregate. Special knowledge was needed for controlling the troop collectives consisting of persons with a high level of general educational and professional training. In taking a decision for combat, moral and political factors assumed important significance. The decisiveness of the aims of a war, its protracted and exhausting nature required a mobilizing of the moral forces of man. For this reason in the process of his command activity, the military leader was obliged to consider the spiritual potential of a soldier.

With the complicating of military affairs, the staff became an authoritative command body granted extensive powers. At the same time, this led to the complicating of its work. The staff bodies began to have a developed structure of services responsible for the activities of the branches of forces and support subunits. The staff now collected information and processed it, it prepared the data necessary for decision taking, and on a day to day basis it controlled the troops, and so forth.

During the years of World War II troop command experienced new difficulties. Due to the increased amount of control functions, the staff found it difficult to handle the fulfillment of its tasks. The situation in postwar times has not changed. Under the conditions of the present-day scientific and technical revolution, there has been a new further complicating of military affairs. This, certainly, has caused corresponding difficulties in the control level. A whole series of contradictions has arisen between the fundamentally new features of military affairs and the traditional means and methods of troop control in combat.

The present stage in the development of military affairs is characterized by a sharp increase in the data important in decision taking. In addition to the information which the commander needed previously, now it is essential to have information on the enemy's weapons of mass destruction, their condition and position, as well as information on the radiation, chemical and bacteriological situation, and data on radar equipment, operational and tactical landing forces. At present, a divisional staff under combat conditions will receive significantly more information than was received by an analogous formation during the years of World War II.

It must also be pointed out that circulating information is extremely dynamic and rapidly goes out of date. At the same time, the commander needs information which precisely reflects the real situation for making a decision. Moreover, he should receive extensive data on the situation more frequently than before. The rate of advance of the troops in the period of the Great Patriotic War made it possible to prepare a summary for the army commander virtually twice a day, and for a divisional commander five or eight times. Under the conditions of modern combat any level of commander, even up to the superior level, will need to continuously study the situation and evaluate the importance of the changing information.

These particular features (the increased amount of information and its extreme dynamism) of the data needed for decision taking have necessitated an increase in the time given for analyzing the incoming information. At the same time, as never before, it is now important to take decisions in the shortest possible time and in individual instances, instantaneously. This is one of the contradictions in the command of troop combat under the conditions of modern combat.

A commander has always experienced a lack of information about the enemy. The incompleteness of data on the enemy is a traditional feature in the command activities of an officer at present. However, under today's conditions, particularly with the threat of the use of nuclear missile weapons, the absence of the necessary data on the enemy leads to ambiguity in the decision to be taken and to mistakes in this. Although the commander presently possesses a large number of technical reconnaissance devices, nevertheless it is no easier but rather more difficult than before to obtain exhaustive data on the enemy. This is explained by the special measures undertaken by the enemy to conceal its true intentions, as well as by the extreme mobility of the troops and the fluidity of their combat.

At present the area from which reconnaissance information must be assembled has increased significantly. For this reason the information has a probable nature, and in a majority of instances will not contain all of the information needed for the taking of a decision by the commander. Thus, under present-day conditions the contradiction has been substantially aggrevated between the incompleteness of data on the enemy, the hypothetical nature of the available data and the vital necessity of exceptional accuracy and soundness in the decisions to be taken.

The intensive growth of the scale of combat, the broadening of the expanse of combat and the increase in the distances at which a fire duel between opponents is possible have led to a significant increase in control communications and to a broadening of the entire control system. It has now come to encompass such a large number of elements that it has been named a "large system."

On the one hand, the broadening of the scale and distance at which troop command is carried out has led to an increase in the probability of a breakdown of individual elements in the system and a distorting of the signal in the command channels. On the other hand, modern armed combat places increased demands on the reliability of the control system. Even a brief failure is fraught with irrecoverable consequences.

In addition to the indicated ones there are also other contradictions. Among them we could mention the contradiction between the necessity of rigid centralization over troop control and the requirement of granting greater initiative to the subordinate commanders, that is, to a certain decentralization of command. In line with the increase in the factors which should be considered by a military leader in his decision, the contradiction has been aggrevated between the terse form of the order and the content which must reflect the entire complexity of the situation and explain the combat missions to subordinates.

Here it is essential to remember that an expectation of complete exclusion of mistakes from control activity of man in general and the commander in particular cannot be considered justified. It is essential to work for the creating of conditions under which the probability of mistakes would be below the acceptable limits. However, considering the lack of information on the enemy, the incomplete reflecting of the objective processes of modern warfare in military theory, the possibility of gaps in the personal professional training and experience of the commander, as well as the action of factors related to a change in the physiological, mental and moral state of a person under combat conditions, it is impossible to completely exclude mistakes from the process of the taking of a combat decision by the commander.

The aggregate of the abovementioned circumstances has caused certain difficulties in providing optimum and effective control over troop combat. The given contradictions have been resolved in several says. One of them

consisted in improving the work of all levels of staffs without a fundamental and qualitative change in their technical base. In the given instance it would have been possible to achieve real results by increasing the number of staff workers. In precisely this way the control activities of the staffs were improved for a rather long time. However an increase in the number of staff workers leads at a certain moment to the complicating of their leadership. The staff becomes overgrown with services, departments, subdepartments and other subdivisions. It becomes cumbersome, immobile and inefficient. Under the conditions of modern armed combat, by such a method it is impossible to achieve a resolving of the arising command contradictions. The other way also has tangible limits, that is, improving the professional training of the staff workers. The problem is that a person possesses completely definite and for certain indicators, very low psychophysical characteristics which impose natural constraints on the intensifying of human activity in the control area. Human reason, in possessing colossal creative capabilities such as surprising flexibility, dynamism and enormous analytical and logical abilities, at the same time is not marked by great speed and is subject to rapid exhaustion. The capacity of the human memory is not great. A set of increased emotionality which is so characteristic for human activity on the battlefield, as a rule, has a negative influence on the use of human mental capacity in the process of troop command.

Historical experience indicates that it is impossible to resolve the contradictions in troop command under the conditions of the present revolution in military affairs by intensifying command activities of a person with the old methods and traditional equipment of command. This has become particularly apparent after the introduction into the troops of missile weapons which possess enormous speed and the capacity for crossing distances of tens of thousands of kilometers in scores of minutes. Naturally, with any level of professional training, a person would be unable to meet the task of controlling such objects. Moreover, the outfitting of the troops with nuclear missile weapons has led to a sharp complicating of the very processes of controlling troop combat. Of course, under these conditions an improvement in the professional training of staff officers remains an important means for raising the effectiveness of his work. However, in and of itself this cannot resolve the sharp contradictions which characterize the present processes of troop control. This must be combined with a new method of resolving the very complicated control problems. And this method is the full automation of control.

The introduction of equipment into control processes has an ancient history. Initially technical devices appeared as means for detecting the enemy. Optical observation instruments for a long time were virtually the only technical control devices. These underwent a significant evolution from primitive observation instruments up to a developed system of advanced optical instruments used both for observing the battlefield as well as for controlling artillery fire, navigation. bombing, aircraft control and other purposes.

On the eve and in the course of World War II there was an abrupt jump in the development of technical detection devices. Sound ranging appeared and was developed and this was employed in combating enemy artillery as well as in air defense for increasing the effectiveness of antiaircraft artillery fire. However the limited capabilities of sound ranging were soon apparent. The discovered shortcomings in the optical and sound ranging detection devices caused the search for new equipment. Radar became the basic technical means of detection. On the basis of radar instruments for controlling artillery fire were designed. Radar became the basic means for detecting the enemy in air defense and antimissile defense. It has been widely used in the navy as well. It would be hard to imagine modern military equipment or the process of controlling troop actions without radar. At present the prospects of its development are linked abroad to the use of laser equipment for superaccurate locating.

Along with the detection equipment, there was also active development in the data transmission means (the means of communications). The complicating of military affairs and the command of troop combat required new means of communications. As is known, for a long time optical means of communications were used for this purpose including smoke signals, all sorts of semaphores, flag signaling systems, and so forth. However the real introduction of equipment into this sphere of control started with wire communications. The development of the telephone, telegraph and radio became an important stage in the development of communications equipment.

At present armed forces have at their disposal powerful means of communications making it possible at any distance to ensure effectiveness and concealment of troop command. It is impossible to imagine the modern process of troop control on any level without communications.

While the area of obtaining information on the enemy, its troops, the terrain, the meteorological conditions and also the transmission of information became rather quickly technologized, in the sphere of data processing this process occurred significantly more slowly. Initially rather primitive instruments which facilitated calculations were used for this such as slide rules, scales and so forth. Then calculators and navigation instruments appeared. For aviation and the air defense troops, automatic control devices were designed such as automatic pilots and AFCE (antiaircraft fire control equipment). The first models of the AFCE were not automatic. They were designed considering the use of a large crew of servicemen the duties of whom had been maximally simplified and consisted of lining up numerous scales, dials and so forth. In the postwar period, electromechanical and later electronic AFCE appeared and these operated without the interference of man. Subsequently automatic control devices appeared in other areas of military affairs. However, these devices involved control over just solitary technical elements such as an aircraft or gun (battery). At the same time the control over large technical complexes and the combat of troops largely remained traditional.

The decisive technical prerequisite for the automation of troop control has been the creation and rapid development of high-speed electronic computers, both digital and analog. Their appearance is usually linked with the development of automation.

The first digital calculating machines were designed in the 17th century by the French scientist B. Pascal, and later by the famous German scientist and philosopher G. W. Leibnitz. In 1874, the arithmometer of V. G. Odner was developed and this was widely used and has existed up to the present. The development history of universal computers is interesting and instructive. The idea of creating them was proposed by the English mathematician C. Babbage. In 1883 he designed a gigantic arithmometer with program control (an arithmetical and storage device). The version of the machine presented by him was close to a modern one. However the ideas of the scientists were so ahead of their time that his contemporaries could not appreciate their merit. Attention to his work was shown only a century later.

The development of computers became a remarkable phenomenon in the development of technology. In 1944, a digital computer operating on electromagnetic relays was designed in the United States, and in 1946, the first ENIAC electronic computer was introduced. In the USSR, the first computer was built in 1950.

Since then computers in our nation have undergone three stages of development. The first generation of computers was developed in the period from 1955 through 1960. They used electron tubes as the basic element. The second generation (1960-1965) was based on the use of semiconductor technology including transistors, diodes, and so forth. The method of printed circuitry, block arrangement and other progressive methods were widely used then. The third generation is the stage of microelectronics. At present our nation is producing computers of this generation in the form of a unified system of machines which have valuable qualities such as small size, an increased volume of the operational and external memory, increased reliability, high speed of the central processor, the capacity for parallel operation of the devices, and the possibility of connecting the machine to peripheral points. The last two qualities are of particularly important significance, for they make it possible for one machine to solve many problems asked by various control points a great distance apart. In this regard the possibility has appeared of creating large data systems (LDS) which could serve a large number of users on the basis of several large computer centers connected by an automated communications system with the peripheral points.

The third generation of computers has enormous speed on the order of several tens of millions of operations per second, and a memory capacity up to 16 million bytes (a byte is a unit of operation equal to eight binary digits, or two bytes = 8 bits). At present the speed of the machines no longer impedes their development. The input and output systems as well as the lag of the operational and external memory have become the bottleneck.

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It is expected that the fourth generation of computers will be characterized by a significantly higher degree of integration in the circuitry in comparison with the third. Over the long run the use of fundamentally new principles for electronic computer design is possible in the form of laser elements. The imperative need of our times for increasing the memory of the machines will be realized in developing external memories for 10^{14} bytes of information. Of course, the sharp increase in the capacity of the external memory should be accompanied by progress in the methods and means of using it.

Computer technology during the short history of its development has been able to prove its importance as an important basis for automating control. The given notion can be seen with particular clarity in the rapid increase of digital computers. The first such machine was developed in 1946. In 1955 there were a few more than 1,000 digital computers throughout the world. In 1963, they numbered around 23,000, in 1964, 32,000, and in 1965, over 45,000. By 1967, 50,000 digital computers were functioning in the world. The number of machines has been growing particularly rapidly in the United States. In 1965, there were more than 22,000 of them, 32,000 in 1967, and 70,000 in 1970. The increase of capital investments into the area of computer production in the United States, for example, has continued to grow. While in 1962, around 2 percent of all industrial expenditures were invested into this sphere of production, in 1966, the figure was already 6 percent, and in 1970, 10 percent. According to a statement in the foreign press, in 1975, the number of computers in the United States has risen up to 100,000.

Electronic computer technology cannot be identified with automation, although it is the basis of automation. Without computers it would be impossible to automate the control of troop combat. Thus, the technical prerequisite for full automation in the form of a computer was not only an important one but also the conclusive one. After it the automation of control began to develop rapidly.

The rise of computers made it possible to move from partial to fully automated troop control. Partial automation encompassed the control of small troop units, that is, small weapons complexes (an aircraft, antiaircraft artillery battery, an antiaircraft guided missile complex, and so forth). Often it made it possible to control combat units under the quietest working conditions and in the absence of an abrupt change in the situation. The operation of an automatic pilot is an example of this.

The local nature of the operation of automatic control devices in a number of instances has not facilitated but rather impeded the leadership of large troop collectives, since the problem of maintaining integrity and the monolithic nature of the entire troop control process has become more complex. Certainly man provided such integrity. Without his participation only individual, most often initial combat operations were carried out. At this stage man was better than automatic devices in performing the

control function in virtually its entire range. Only in the most acute and intense areas (for example, aviation, air defense, and so forth), because of the increased speed of the equipment, did constraints imposed on the control process by man begin to be felt. Partial automation was introduced precisely in these areas.

Troop control in combat consists of two different processes. The first is the control of the equipment. Any technical device or system of them has a rather rigid program of operation. This feature makes it possible to develop an automatic control device which controls it within the complete range of the entire accepted program for the activity of the technical system. Such control systems are called automatic (SAU). They organically combine a high and comprehensive level for mechanizing a certain military action with the complete automation of its control. The automatic military control systems do not require the direct participation of man. The acting principal of control is outside such systems. He intervenes in their work only in the event of emergency situations, the failure of the equipment, for carrying out adjustments, and in the period of setting up the system. Naturally a man creates automatic systems, he designs them, he works out the program of their operation, and so forth.

For a certain time in the literature on the problems of automating control, there prevailed an overly optimistic notion of the possibilities of developing automatic control systems. Thus, in particular, proposals were made on the possibility of creating automatic control systems for not only large complexes of military weapons but also for troop combat. However, it very quickly became apparent that the second type of control is significantly more complicated than the first. Certainly it is the control of people, the troop collectives, and includes consideration of such processes as the moral-psychological state, the level of responsibility, professional training, and so forth.

For this reason the complete isolation of man outside the troop control system is an impossible matter for many reasons. In the first place, research on the fundamental possibilities of automation showed the unsoundness of completely eliminating the acting principal from the control system. Secondly, even in assuming the probability of developing such systems, they must be given up due to their complexity and unreliability in operations. From all viewpoints it was significantly better with a given level of automation to introduce man into the control system, and he would assume the carrying out of the most crucial tasks requiring creative effort and high skills in troop command. Such systems, in contrast to automatic ones, are termed automated. Their appearance was the result of solving the abovementioned contradictions arising due to the complicating of the process of controlling troop combat, on the one hand, and the difficulties of developing automatic systems, on the other.

Although the development of automatic weapons control systems has great promise, the possibilities of it are not the same for the various types of military equipment. Those types which are directly employed in combat,

in a direct contact with the enemy, require direct articulation with man and form a single system with him. These are tanks, guns, direct support artillery, naval ships, a majority of combat aircraft, and so forth. Here man has assumed and will assume a direct part in control, being here the main element of the control system and the acting principal of the control process.

The necessity of incorporating man as a direct element in the control system is dictated not only by the specific features of one or another type of weapon but also by the scale of combat. While on a level of the actions of individual weapons units or small weapons complexes it is possible to create closed automatic control systems, with an increase in the scale of combat, they more and more express their social nature in acting as a specific area of the activities of human masses and troop collectives. It is no longer a question of controlling equipment but rather controlling people and troop collectives. This is why the automated troop control systems (ASUV) have been developed.

Precisely such systems for the control of troop combat make it possible to achieve full automation of control. Full automation of troop control is a stage of automation whereby all the elements in the process of troop control (the collecting, processing and analysis of data on the situation, the working out of variations of optimum decisions, the issuing of orders and instructions to the troops, as well as control over their fulfillment) in all the control elements should be carried out using universal algorithms and programs.

Full automation is characterized by a systems approach in solving the problems of troop control. This cannot be reduced merely to the introduction of automatic and automated equipment. If full automation is conceived of as the simple technologization of the control process with the maintaining of the old style, methods and ways of control, then such an improvement in control has outlived itself. Automatic and automated control equipment bring an effect only in the event of the optimization of control, an improvement in the structure of the controlling organs, and the careful thinking out of their coordination and subordination. Full automation should lead to a fundamental revision of control over troop combat. At the same time it is the expresser of this reorganization.

Consequently, full automation of control over troop combat is a complicated process the occurrence of which is brought about by many factors. Some of them derive from the difficulties and complexities in the development of military affairs. Others are caused by social needs which encompass a broader area than military affairs. However, the need for a positive change in control still does not mean an improvement in it. There must be the scientific and technical prerequisites for solving this problem. The complex intertwining of the internal factors and the external prerequisites for the rise of full automation in the control of troop combat is an example of the relationship of science and social practice and their dialectical interdependence.

3. Scientific Bases of Automating Troop Control

The question of the scientific bases for automating troop control has been and is posed more acutely than in other spheres. Thus, the designers of the first automatic devices relied almost exclusively on their inventiveness, common sense and empirical choice. Even in the age of cybernetics, in the various spheres of automation, the degree of scientificness depends upon the complexity of the systems which are to be automated and upon the level of responsibility of the design decisions.

In the area of automating troop control, the necessity of a high level of scientificness is dictated by the particular complexity of the structure, by the diversity of the functions and conditions in the activity of the systems, by the fundamental newness and their high cost, and mainly by the ever increasing dependence of the combat capabilities and readiness of the troops upon the advanced nature and reliability of the control systems. In automating relatively simple systems, the essence of the processes is often disclosed by an empirical study, and a successful solution is sought out by choice. In systems of such a level of complexity as the ASUV, the seeking out of solutions is possible only on a basis of a scientific approach to automating troop control.

The given question would not require special discussion if there were not a number of methodological difficulties which arise in solving it. As was already pointed out, ASUV is systems which without fail include a principal of control. For this reason the research is not restricted to analyzing one or two relatively simple forms of the movement of matter, but rather encompasses their entire spectrum, including biological and social aspects of the processes. Thus, the scientific bases of automating troop control cannot be restricted to a relatively narrow range of military technical disciplines. For analyzing the functioning of the ASUV, the physiology of sense organs, human factors engineering and the psychology of thought, pedagogics, logic, semiotics, linguistics and so forth are involved. However many of these areas of knowledge themselves have not yet achieved the necessary level of methodological maturity. Certain provisions of the designated disciplines themselves need a further philosophical-methodological and logical-gnoseological basis. All of this requires clarity and profoundness in a methodological analysis of the scientific bases for automating troop control.

First of all it is essential to bring out what a scientific approach to automating control is, what is its difference from an empirical approach, and what are the levels of the required and actually existing scientific soundness of the design and organizational decisions in the various stages of automating different control systems. The problem is that in recent years, in line with the greater role of science in improving control, that control which in its scale and methods is the traditional empirical type is often defined as "scientific." In this instance, science becomes, in the expression of V. I. Lenin, "a dead letter or a fashionable phrase,"

but is not turned into "an element of everyday life completely and truly." For this reason it is so important to disclose the distinguishing features and traits of a truly scientific approach to automating control systems generally and troop systems, in particular.

With each passing year the elaboration of the theories and disciplines comprising the scientific basis of automation is extended. In accord with this, the boundary between theoretical and empirical knowledge, scientific and traditional activities in this area is shifted. Being historically determined, the notion of "scientific bases of automation" changes along with the development of its theoretical base, with the introduction and development of new technology, and with a rise in the level of training of the specialists operating it.

However, regardless of this relativeness of the scientific and empirical principles of control, they can be delimited rather clearly.

The making of automata began long before the appearance of the theory describing them. Over the centuries this has been based on common sense, experience and practical skills. Even when a theory of automatic control had been created by the works of Maxwell, Chebyshev, Vyshnegradskiy and others, automation did not gain a completely sound basis. At the outset of its development science took more from practice than it gave it. Initially science merely explained the practical achievements and performed the function of instruction. Science began to outstrip practice only when it learned how to forecast the processes and to predict and foresee the specific trends and patterns. Only from this moment could the use of the methods, conclusions and recommendations of science make a substantial imprint on practice and also make the expressions "scientific approach" and "scientific bases" valid.

Moreover, along with a profound relationship, there is a substantial difference which exists between the manufacturing of individual automata and the process of full automation which emcompasses a rather extensive sphere of industry or military affairs. For this reason their scientific bases are also somewhat different. For an analysis and synthesis of the individual automata, the theory of automatic control is used as the basis along with the theory of discrete automata and technical cybernatics. But the scientific basis of automation is founded primarily on the theory of operations research, military and economic efficiency, queueing theory, the methods of systems analysis, linear and dynamic programming, and so forth.

At the same time, for automating such complex systems as troop command, there must be the aggregate knowledge of all sciences which comprise the theoretical foundation of automation. That is, they should have a uniform conceptual fund, a common apparatus and similar methods. According to certain scientists, in automating "large systems," intuition and search still prevail over theory and calculation. The basic reason for this resides in the local or "patchwork" approach of the modern science on control to describing systems and processes and to their mathematical treatment.

What determines the gradualness of the transition from empiricism to scientific methods of analysis and synthesis of various automated systems? In the first place, the objective complexity of the systems to be automated and the conditions of their functioning. Secondly, by the development level of science in a given period, that is, by the availability of the corresponding means and methods which ensure the study of the systems and the processes of certain complexity. Thirdly, by the degree of practical necessity of automating systems of the studied class, by the concentration of the forces and means of science in the given area.

In any concrete systems, it is not hard to isolate the elements for which the degree of the scientificness of the approach to automation varies. The history of automation shows that the technical, logical-mathematical and economic problems of designing the ASU have reached the necessary level of scientificness far from simultaneously. In automating troop control, the primary role is played by the particular features of the development of military art. Initially the military researchers, as is known, did not separate the processes of troop control in the course of solving a tactical problems from its content. The question of "how to control?" was not separate from the question of "what to control?" and a differentiation of the means and goal was also lacking. Since the goal positing in the control element always prevails over the means and methods, the goal content of control became a subject of scientific research before the technology of control activity. Thus, troop control initially became scientific in terms of its goal content and only later in terms of methods and means.[9]

Since automation in the designated area is not an end in itself but rather the means for improving the efficiency of troop control, it gains a firm scientific basis from the moment of turning management activity itself into an object of research, when the formal-apparatus and structural aspect of control begins to be specially analyzed.

The degree of the scientificness of troop control and the automation of this process is directly dependent upon the entire system of modern scientific knowledge on control. For example, a major contribution to elaborating the problems of troop control was made by military scientists before the appearance of cybernetics. However in the research founded on a military base per se and on a conceptual apparatus of just the theory of military art, the general was often subordinate to the specific and the essence of the processes was not fully disclosed. For this reason the scientific forces, knowledge and funds were frequently spent on the discovery of patterns already known in other areas of control. Cybernetics created a common basis for transferring the ideas, it disclosed their reciprocal influence and intercausality, it avoided the primitive methods and exclusiveness, and provided a strong conceptual and logical-mathematical apparatus. All of this helped to raise the level of the scientificness of the approach to improving the systems of troop control.

The degree of scientificness of the approach to automation depends substantially upon whether or not automatable processes are being studied only

in a qualitative form or whether their strict quantitative relations are being defined. In a number of instances, for creating the ASUV it may be sufficient to have only the qualitative characteristics of the controlled process. However, in designing an optimum (in the tactical, technical and economic sense), it is essential to know the quantitative dependences.

The scientific establishing of the principles of automating troop control requires not only scientific cognition of the systems and processes of control, but also scientific procedures and methods of human activities in all stages of working out and designing the ASUV as well as in the course of its exploitation and combat use.

At the same time, it is essential to distinguish scientificness in the narrow, specifically military and military technical manifestation and on the broad, general theoretical and philosophical methodological level. The first level with the absence of the second can provide an effect only in solving particular problems on the military technical and tactical level. And often only the appearance of scientificness occurs. In actuality, the incorrect solution to the question of the balance of the objective and the subjective in a war, the relationship of man and equipment, and the dialectics of creative and algorithmic (reproductive) thinking will scarcely make it possible to talk seriously of a scientific approach to the studied problems, although here an advanced logical and mathematical apparatus can be employed and a high level of electronic machine building technology can be ensured.

Thus, automating troop control can have a truly scientific character under the condition of basing its principles on the dialectical materialistic ideology and methodology, and on the theory of scientific control of the socialist society and the Marxist-Leninist teachings of war and the army.

These, in our conviction, are the basic traits of a scientific approach to the automating of troop control.

It is possible to isolate a number of specific traits which are characteristic for the process of automating troop control in the armies of the most advanced nations of the world.

1) The theoretical basis for the analysis and synthesis of automata and systems is changing. Cybernetics and its related disciplines have made it possible to commence a transition from the use of very simple automata (program, tracking and stabilizing) to adaptive, self-adjusting, self-instructing and self-organizing. In acquiring a reliable theoretical base in a systems-cybernetic approach, automation is becoming a common scientific-methodological approach to solving the problems of raising the effectiveness of weapon and troop control. All of this makes it possible to avoid primitive inventiveness in solving each particular question.

2) The technical base of automation is changing. The pneumatic, hydraulic and electromechenical devices have been replaced by electronic automata,

initially vacuum tube, and then semiconductor, micromodule, printed, film and solid-state circuits. As a result the speed and reliability of the automata have risen, while their size and required power have declined.

3) The range of processes which can be automated have been substantially broadened. While previously mainly the processes of the conversion of matter and energy were automated, at present basic attention has begun to be paid to automating information processing. A characteristic trait of this new phase is the introduction of control automata. For them the very control information is the object of control. Among such automata one would put calculating, information-logical, information retrieval, modeling and other devices. Any automaton provides control by the receiving, processing, transmitting and storage of information. Control automata differ from the servomechanisms in the object of control which for them is the control information. The appearance of control automata has led to the creation of an hierarchy of automated devices which predetermine the conjugation and coordination of the work of the automatic servodevices and, consequently, have made possible the transition to full automation.

4) The sphere of use of automata has broadened. To the only previous area of technical devices, two new ones have been added: the "man--machine" system and the "collective--machine" system. The components of the former are man, the control and actuator automata and the object of control. The second includes collectives of people, complexes of control and actuator automata and complex objects of control. Automation encompasses not only weapons and individual models of military equipment, but also entire tactical units (ships, aircraft and combat complexes), as well as systems of troop control. Here precisely the creation of ASUV becomes one of the most characteristic and specific traits in the period of automation in the armed forces, since the systems of troop control are systems of the open type. In literature a distinction is drawn between open and closed control systems. A systems is termed closed when the choice of the questions to be solved in the process of its functioning remains fixed. The data which are not developed in the process of the functioning of the system are realized as a result of a single elaboration, for example, an antiaircraft missile complex, and so forth. A sysem is termed open if it develops with a set of basic problems which changes in the process of functioning. Such systems cannot be created as once and for all complete. By their very essence they should be constantly self-improving in the process of their functioning. Understandably it is significantly more complicated to automate such systems. But systems of military-political leadership and troop control should be precisely of this type.

5) The close tie of automation with other methods and measures related to optimizing the systems and processes of control, and namely with the use of the methods of operations research and combat efficiency, the scientific organization of labor [NOT], human factors engineering, industrial design, and so forth. Automation acts as an element of the system of measures to raise the combat capabilities of the troops. And this link is particularly apparent in automating troop control.

All these particular features of the present stage of automation in the armed forces are vividly apparent in the course of automating troop control, they mark an unusual broadening of the scientific base of automation, and they are the source and impelling motive for the further development of its scientific and technical bases.

Sometimes the problem of the scientific bases of automating troop control is solved from extreme positions: either only military cybernetics is viewed as such, or nearly all the presently existing scientific disciplines and theories are put among the sciences comprising this base. In our opinion, the problem of troop control and the principles of creating ASUV can be worked out only on the basis of the dialectical materialistic understanding of the general, the particular and the individual.

The patterns which determine the structure of the systems and the nature of the processes of troop control can be divided according to the degree of their commonness into several levels. First of all it is essential to isolate the general patterns of the material world which are not specific precisely for control systems but appear in them. Among such patterns are the primacy of the material in relation to the spiritual, the determinacy of processes and phenomena, and the objectivity of the development sources. In analyzing the specific systems, the universal patterns must be considered. Otherwise this analysis can be abstract or one-sided, since the individual and particular will be viewed without the general. Marxist-Leninist philosophy--dialectical and historical materialism--is the scientific basis for examining the universal patterns which are apparent in the systems of troop control.

It is also essential to isolate a group of patterns which are common to all systems, regardless of their specifics. As is known, the term system is given to sets of specifically related elements which possess a relatively stable unity and a latent integrity. And the internal ties of the system are noticeably more numerous and important than the external ones. All of this gives rise to the so-called integrative or system properties which are not identical to the total of the properties of the elements of the system.

Although the designated features are inherent to all systems, however a consideration of them helps to more fully imagine the structure of the systems of troop control. The scientific basis for examining the given range of patterns is the presently developing general theory of systems, within which a systems approach to studyint complex objects is being established. With the aid of this method, the correlation is disclosed between the components of an integrated system. The dialectical materialistic principle of the relationship of the phenomena and processes of the material world is the methodological base of a systems approach.

The next group of patterns which are apparent in systems of troop control is made up of the general laws of control which are inherent to all control

systems, without exception, for they are linked to the profound essence of control as a process of the goal-directed effect of the control organ on the controlled object and carried out by the transmission, processing and storage of information. The scientific basis which provides for the study of such patterns in troop control systems is theoretical cybernetics which examines the systems and processes of control of any material nature and complexity.

Equally important are the general patterns inherent to all social systems, including control systems. The theory of the scientific control of society operates as the theoretical basis for optimizing and automating troop control systems, and this theory has its own scientific bases related to the materialistic understanding of history, the interpretation of historical determinism, the development patterns of the given socioeconomic formation, and so forth. A truly scientific theory of control of society has formed on the basis of historical materialism, the theory of scientific communism and Marxist sociology. Its provisions, principles and theoretical bases are the scientific basis for studying and improving all the troop control systems in the USSR Armed Forces and in the armies of the other socialist countries.

The common patterns of troop control determine the structure of the systems and the nature of the processes occurring in them outside a dependence on the service of the armed forces and the branch of forces, the rank of the given command level, as well as the presence or absence of automation and equipment for employing logical and mathematical methods. All troop control systems are designed to function under the conditions of conflict situations related to the opposition from the enemy, a shortage of time and the enemy's desire to anticipate a control effect, to the increased responsibility of the decisions to be taken, the incomplete and partially false information, to the presence of intentional interference and the enemy's desire to knock out the controlled objects and the very control system. For this reason, successful automation of such systems is possible only on a scientific basis of the general theory of troop control and this, in turn, is guided by the methodological principles of the Marxist-Leninist teachings on the war and the army, by the tenets of military science, the theory of military art, military pedagogics, military psychology, military legal and other sciences, that is, the entire system of military knowledge which directly or indirectly is used in studying and improving the troop control systems.

A specifically separate group is made up of the patterns inherent to the given service of the armed forces, branch of forces, and the specific level of control and type of combat. They, respectively, are studied by the theory of operational art and by the tactics of the given services of the armed forces and branches of forces, and by the theory of the types of combat (offensive and defensive operations and combat). Any attempt to create an ASUV without considering these specifically concrete data of the theory of military art will be unsuccessful, for the individual is richer than the common.

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Such are the dialectics of the common, the particular and the individual and, respectively, the subordination and coordination tie of the patterns which determine the structure and functioning of any control systems.

A most important feature of the ASUV is that these are automated systems. In turn, automation in any sphere has its own patterns which require consideration and study. Only having elucidated the link of automation with the entire history of the development of technology and its genetic dependence on mechanization, can one solve many cardinal questions on a methodologically correct basis. For example, the relationship of man and equipment in the ASUV, the problem of the "replacing" of man by an automaton, the relationship of mental and physical, creative and routine labor in such systems, or the prospects for automation and the dynamics of military professions. The general theory of automation is becoming the scientific basis for studying the patterns on this level.[10]

Consequently, the scientific foundation for the automation of troop control is made up of theories which study the patterns of a specifically military, general social and technical order. Attempts to ignore any of these can cause undesirable consequences. Thus, in American military technical literature of recent years, quite legitimate complaints have appeared that certain ASUV which have been put into effect did not justify their hopes. In the opinion of the specialists, the approach to their designing was "too technical," and did not consider other aspects. A comprehensive consideration of the patterns of all the above-listed levels is one of the important methodological principles in the approach to automating troop control.

Military cybernetics is the direct scientific basis for the automation of troop control. This arose as a section or offshoot of the science of cybernetics. As is known, due to the works of N. Weiner and other scientists, at the end of the 1940's a special science developed on the laws concerning the structural organization and functioning of control systems of any material nature and complexity. Cybernetics has as its task the analysis, synthesis and automation of such systems for the purpose of their optimization. Initially it was an area of knowledge on the general laws of control. At that time it would have been premature to speak of military cybernetics as an independent area of knowledge. It was merely a question of the use of cybernetics in military affairs. Later on a division was noted into theoretical, technical and applied cybernetics.

Theoretical cybernetics is marked by a maximal commonness of problems and in any control systems examines only the isomorphic and nonspecific phenomena. Military specifics had not yet been manifested to the point where the differences began to prevail over the similarity. Certainly in terms of theoretical cybernetics even now it is proper to speak only of its use in military affairs.

Technical cybernetics examines the problem of the engineering realization of control, information, modeling and computational systems of any (including military) purpose. Naturally, the specifics of armed combat tell on

the demands made upon the military cybernetic devices, as they require high speed, resistance to jamming, reliability, low weight and small size. The questions of economy should be solved differently, and here the coordinating of the equipment and man is carried out considering the mental state of the soldier under the conditions of increased danger, responsibility and a lack of time. Nevertheless, all these particular features are considered mainly in the posing of the problems and in formulating the tactical and technical requirements for these systems. But the methods of the analysis and synthesis of systems do not undergo any essential changes. The ordinary methods of technical cybernetics, human factors in engineering and so forth are to be employed. For this reason, in these instances one also speaks not of military cybernetics but rather of the application of cybernetics in military affairs.

Applied cybernetics is a different question. Its task includes examining specific control systems in specific areas of activity and the elaboration of effective methods for employing cybernetic means and methods in these spheres.

A classification of the areas of applied cybernetics (economic cybernetics, biocybernetics, and so forth) is determined by the specific features of the subject of examination, by the alteration caused by it in the methods, means and tasks of study, as well as by the particular demands on training research personnel. The specific features of military control systems have caused the separating of military cybernetics as an independent offshoot of applied cybernetics.

Military cybernetics has redistributed the proportional amount of research methods and tasks, it has hypertrophied some of them and shifted others to the background. For example, game theory which was developed by J. von Neumann and O. Morgenstern, being one of the many disciplines of general cybernetics, in the military area has moved into a situation of the leading area of knowledge. This theory was specially created for solving problems containing conflict situation. With its aid it is possible to create models for the behavior of the enemy under various circumstances.

The basis of the arguments in game theory is the supposition of the enemy as a rational opposing side which can upset our plans and prevent us from achieving the set goal. Thus the specific features of armed combat are manifested. Undoubtedly it is possible to represent the actions of a shop foreman in a production process as a "game." Such models are valid but they are not necessary. But for disclosing the specific features of military control, game theory represents the most suitable mathematical apparatus.

This offshoot of cybernetics also solves problems concerning the elaboration of special methods of decision taking under the conditions of incomplete or even partially false information, the problems of evaluating reliability, the promptness and completeness of combat information, as well as a number of other specific military problems.

Thus, military cybernetics is an offspring of applied cybernetics which should solve specifically military problems. Since specific military features are most clearly apparent in the systems and processes of controlling troops, combat complexes and tactical units on the battlefield, in the literature a tradition has developed of localizing the term "military cybernetics" chiefly in this area of military affairs. But in terms of the weapons control systems, the "man--military equipment" systems and in the control systems for troop supply and the military economy, the problems of military cybernetics consist in working out the tactical and technical requirements and specifications, of "linking" these to the strategic, operational-tactical or tactical background, the formulating of the specifically military characteristics of the control objects in the language of cybernetics and the military interpretation of the results of their cybernetic examination. All these problems require special military knowledge, and cannot be solved on the basis of just the general provisions of cybernetics.

In structural terms, military cybernetics is divided into a number of independent areas of knowledge: Information theory (the theory of military information, the military applications of information theory, and so forth); operations research (the theory of operations research, the theory of studying combat, the theory of applying mathematical methods for solving military problems); the theory of the algorithmization of military problems (the elaboration of algorithmic descriptions of combat and the processes of its control); the theory of military-purpose control systems; the theory of automating troop control; the theory of the military application of electronic computers, and so forth.

Modern military cybernetics is a most important element of the scientific foundation on which the automation of troop control is developed. Obviously its role can be noticeably increased if its structure is organized not by the "apparatus" principle but rather according to the specific functional one. At present, the sections of military cybernetics unify an apparatus of a single type: information theory, algorithmic, and so forth.

Each of them can exist independently of military cybernetics. For this reason at present much work in operations research, the use of SPU [network planning and management], and the automation of troop control contains no reference to military cybernetics. To put it figuratively, in the present structure of military cybernetics, the research apparatus for the systems and processes of troop control is represented in a march formation and not in deployed battle orders. Possibly, such a structuring of the theory is more economical in the sense of studying the logical and mathematical apparatus used in military cybernetics. But the goals, tasks, objects and the comprehensive approach to their examination remain undisclosed. Obviously in the future there must be a reorganization of military cybernetics precisely by the specific function principle. Then in one section it will be possible to assemble everything that serves the purposes of analysis, synthesis, optimization and automation of the control body, and in another, the necessary information for examining the characteristics of the object of control, and so forth.

The designated structure of military cybernetics is characteristic only for its present state. It will be altered, on the one hand, depending upon what theories and scientific disciplines in the future will be more effective for solving control problems in the military area, and on the other, upon the direction and development pace of the areas of military science which come into contact with military cybernetics.

For example, even now modern statistical information theory successfully solves problems for improving the resistance to jamming in communications, optimum coding, reducing redundancy, and so forth. At the same time, it is not sufficiently effective in determining the value, significance, reliability or promptness of the information, that is, the parameters which are particularly important for military affairs. With the rise of a theory which solves the designated problems, it can be incorporated as part of military cybernetics, without reducing the importance of statistical information theory.

Military cybernetics, has the scientific basis for creating the ASUV, as a whole depends upon the further development of military science generally and each of its sections. In their aggregate they study the laws of armed combat on the strategic, operational and tactical levels, and they elaborate the principles, means, methods and forms of conducting combat, the scientific bases of their planning, support and the organization of troop control. Ultimately, the theory of military art and military science as a whole must answer the practical question of "how must the troops be controlled in all the stages of their activities in order to be victorious over the enemy?" Consequently, not only military cybernetics is concerned with the problems of troop control. Certainly there is a crucial difference between the mentioned areas of knowledge. Military science studies armed combat and the armed forces completely, that is, from military, political, moral-psychological, economic, scientific-technical and other positions, including from the viewpoint of the "technology" of troop control. Military cybernetics examines the same problems, but on the level of control systems and processes with the aid of specific logical and mathematical means. While military science, proceeding from the policy of the state and its military doctrine, determines the aims of combat and sets the criteria for evaluating its military results, military cybernetics accepts these views as given from the outset, and studies the troop control systems and the processes occurring in them with the task of seeking out the most advantageous ways for the practical implementation of the set decisions.

Military cybernetics examines the laws of armed combat as a mathematical science, that is, from the viewpoint of their structure, forms and quantitative relationships. It translates the semantic operational-tactical, strategic and military economic problems into the language of algorithms, information theory and machine programs, and solves them in an abstract quantitative form, while the obtained knowledge becomes available for the theory of military art. The given sector of science carries out the assignments of tactics, operational art and strategy, and serves them like the other military technical sciences.

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In recent years the theory of troop control has been consistently worked out and organizationally shaped as part of military science. This theory in terms of its problems and the range of studied phenomena overlaps and incorporates military cybernetics, and serves as the next stage of its development. This theory, being an organic part of military science, studies the problem of troop control as a whole. Here a sound analysis is made not only of specifically military but also methodological, sociological, legal, moral-ethical, psychological, pedagogical and physiological aspects of organizing control systems, their automation, the recruitment and training of personnel, and so forth.

Obviously new areas will appear along with the development in the theory of troop control. For example, these will be: The principles for the algorithmization of troop control processes; studying the means and methods of automating the receiving, transmission and processing of military information; full automation of troop control systems; the organization of information and computer centers and communications systems; studying the methods for carrying out operational calculations; the use of SPU methods, mechanization and NOT in control systems; the use of the methods of human factors engineering, ergonomics and psychointellectualistics in ASUV, and others.

The common traits of the dialectics of the cognitive process are manifested in the process of understanding the patterns of troop control. Cognition moves from an undifferentiated approach, when the control problem has still not become a distinct one, to an abstract cybernetic one which separates the form of control from its operational or tactical content, and then to the synthesis of a formal control and concrete military analysis which is achieved in the modern theory of troop control.

In turn, the synthesizing theory of troop control reflects the general patterns of the differentiation and integration of scientific knowledge. Thus, the theory of troop control is genetically linked not only with military cybernetics but also to other areas of military science. It can be viewed as an unique result from the development of certain areas of tactics, operational art and strategy. Being a substantive theory, it examines its own systems and processes in the entire completeness of the general, particular and individual, and thereby fills in the missing links in the scientific foundation of automating troop control.

The troop control systems and the processes occurring in them are the most complex objects of automation. They possess traits which are common to all control systems and processes, and at the same time have essential features which must be considered in solving the problems of the possible limits and ways of automation. Proceeding from this it is essential to elucidate the general and particular features of troop control systems as objects of automation, and to characterize the content and essence of the troop control process for defining the conditions and limits of its automation.

FOOTNOTES

1. See K. Marx and F. Engels, "Soch." [Works], Vol 23, p 383.

2. V. I. Lenin, "Poln. Sobr. Soch.," Vol 1, p 100.

3. Ibid.

4. K. Marx and F. Engels, "Soch.," Vol 30, p 264.

5. Ibid., Vol 23, p 384.

6. Ibid., Vol 12, p 735.

7. See SOVETSKAYA VOYENNAYA ENTSIKLOPEDIYA, Moscow, 1976, Vol 1, p 75.

8. See K. Marx and F. Engels, "Soch.," Vol 20, pp 170-178.

9. It is not difficult to be convinced of this in examining regulations, orders and manuals in a chronological order. An analogous sequence can be observed in the development of the theories of control of social processes, economics and technical devices.

10. It must be pointed out that the general theory of automation has not yet developed as an independent discipline. However one can definitely point to a number of works on the methodology, history, the economic (and military) effectiveness of automation, as well as on the forecasting of its prospects, and on technical cybernetics and these comprise the basis of this theory.

CHAPTER 2: TROOP CONTROL AS A SPECIFIC OBJECT OF AUTOMATION

1. Particular Features of Troop Control Systems as Objects of Automation

The questions of improving the systems for controlling social processes occupy an important place in the theoretical and practical activities of the CPSU, and the party has indicated the basic areas and methods for solving this problem. One such area is the creating of sectorial automated control systems, and over the long run, a statewide system for the collection and processing of information. The materials of the 24th and 25th CPSU congresses particularly emphasized that this work should be based upon an analysis and improving of the organizational structure of control and on the establishing and clarification of the functions of the individual bodies. All of this applies fully to troop practices.

The provisions formulated by the party are the initial principles for examining and improving the control systems for the Armed Forces of the Soviet state. In viewing them as objects of automation, it is essential to form a clear notion of the material substrate, the external ties, the internal structure and the functions performed as integral systems and as individual elements and bodies. Here it is important to disclose the specific features of troop control systems (SUV) along with the common ones.

Cybernetics has defined the most general laws for the structure and functioning of all systems. On this level the SUV is a related aggregate of control circuits which ensure the proper functioning of such complex and dynamic systems as troop formations are. Each circuit includes the control body, the controlled object and the direct linkage and feedback channels which connect them. In the process of the functioning of the system, the control body receives and processes information, it generates programs of action and issues the corresponding commands. The object of control by a method specific to it alone carries out these commands. Here over the direct linkage channel command information is sent out from the control body to the object, and over the feedback channel initial information is returned on the state of the object and the surrounding medium (including the object of immediate action), as well as the monitoring information on the results of carrying out the received commands. This is the general picture for the functioning of a SUV from the viewpoint of cybernetics.

To this scheme it is possible to add only several refinements. As is known, in any developed control system, the control body and the controlled object themselves are complex systems and at the same time frequently operate as elements (components) of other, even more complex systems. Ordinarily the control body is connected with several controlled objects among which exists a division of functions. In turn, the control body itself operates as a controlled object for the superior control body of the given system.

As was already pointed out, among the various controlled objects, some carry out predominantly a material-energy interaction of the system with the medium and other objects, others realize mainly informational interactions, and provide for the collection and transmission of initial, command and monitoring information. Regardless of the close interaction and even the interpenetration of both types of functions, it is essential to distinguish them for correctly posing the question of automating their control. Certainly the automation of control must encompass the information cycles and elements of the system which in one way or another are related to the receiving, storage, tranformation and transmission of information.

The further penetration into the problem of automating the SUV requires a thorough structural and functional analysis of these elements in the control body and the controlled objects. However, these demands lead us beyond the limits of a general cybernetics approach, and direct us along the path of the ever more complete consideration of the specific features of troop control systems.

The social nature of the systems is of fundamental significance for solving the problems of automating the SUV. Being subsystems of the larger control system, the Soviet state, they embody the corresponding socioeconomic, political and ideological traits of our system and the socialist way of life.

A number of important consequences ensue from this particular feature of the troop control systems. Since the material substrate of the SUV is people and the equipment created by them, control in the systems is realized through interhuman relationships as well as relationships between humans and equipment. And man is the chief element of the social control system and the interpersonal, group and class relations are the leading ones. They express the production relationships which have come to be in a society.

Each individual is given an awareness and will. He is motivated by material and spiritual needs which have accumulated in the aims and means of achieving them. For this reason, in describing the specifics of the SUV, it is essential to particularly emphasize the role of the subjective factor, the moral-political and military qualities, the mental capacities, knowledge and experience, the purposefulness and will, self-discipline and organization of all the personnel. The science of controlling social processes to a significant degree is human science which requires consideration of the social and psychological makeup of people, as well as the observation in

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their relationships of the legally established standards, rules of human intercourse and moral principles. The most important tasks of control in this regard are the training and indoctrination of the personnel, the uniting of them into a close-knit military collective capable of carrying out a combat mission under a situation of any complexity, and the creation of a healthy psychological climate in it. All of this must not be forgotten for even an instant in setting the tasks of automating troop control and in the process of their practical realization.

Another proof of the social nature of SUV is that, in addition to the subjective factors, in the SUV there is a complex intertwining of objective ones. These are influenced by the natural phenomena (geographic, meteorological, and so forth). At the same time, the SUV find themselves in a complicated intersecting of social factors including: economic, political, ideological and psychological which are not only different in terms of their nature but also frequently operate in different directions. In their aggregate they form the objective conditions for the existence and functioning of the SUV. Only a correct understanding and consideration of the listed features make it possible to mentally pose the question of the necessity and possibility of automating troop control.

The designated traits are specific and at the same time they are common to all social control systems. We, certainly, are interested in those specific features which distinguish SUV precisely as military control systems. This has been analyzed in detail in the work by the collective of authors "Principles of Troop Control."[1]

Without taking up the generally known facts, we would like to treat those notions which are of essential significance for solving automation problems.

Military control systems are designed for functioning in a typical conflict situation, in that specific variety of this which is armed combat. The specific focus of the SUV is aimed at providing the constant and high combat readiness of the troops in peacetime, and in the event the aggressor starts a war, to carry out the combat missions, to achieve victory, and to defeat the enemy in the minimally short time, with the least losses and material expenditures for one's troops.

However the enemy pursues the same goal in relation to our troops. Any battle or operation in this regard is a very complicated two-sided process in which each of the sides endeavors to destroy the enemy not only by the force of arms but also by the force of human reason, and impose one's will on the other side. As a result an unique control system arises in which there are two subsystems at work which endeavor to extend the control effect to the enemy and thereby to the entire process of armed combat.

This particular feature of the control of combat was precisely pointed out by M. N. Tukhachevskiy. "...Only that side," he wrote, "actually directs its actions which achieves the development of them in accord with its own plan, and this means the actual control of combat should be control over the

entire combat process, that is, not only over one's own actions, but also to some degree to the enemy actions imposed on it by our actions.... The art of controlling combat requires an understanding of this complex contradictory process."[2]

The use of weapons by both sides gives rise to a situation of danger in which not only controlled objects operate but also the control bodies. This complicates the work of the latter, it disrupts the communications channels, it sharply alters the state of the controlled objects, it causes both positive and negative emotions in the personnel, and so forth. Under the given experimental conditions [sic] a particular straining of physical and spiritual forces is necessitated from all the personnel in order to correctly carry out the entire aggregate of control operations. The responsibility of the commanders and staffs is increased not only for carrying out the combat mission but also for the life of subordinates, for the fate of the civilian population, and on a strategic scale, for the fate of the motherland as a whole.

The nature of the tasks and conditions of troop control poses sharply the problem of the optimization (raising the efficiency and soundness) of the decisions being taken, since mistakes in them can lead to severe, at times irreparable consequences. The taking of the most effective and sound decisions under these conditions is a very complicated task. This is caused by a number of circumstances: a) by the incompleteness and unreliability of a number of initial data concerning the situation, and particularly on the enemy which will endeavor by all means to conceal its grouping, the plan of action, and confuse us; b) by the complexity and limited possibilities of a mathematical description of combat since it is difficult to give many data a precise quantitative measurement; c) by the limited possibilities for varyfying the degree of optimality of the decision prior to combat in line with the essential incompleteness of any models by which the forthcoming combat could be reproduced and played out.

All the listed factors in a definite manner influence the solving of the problems of automating SUV. On the one hand, the resistance of the enemy, the situation of danger, the intense nature of control work, and the complexity of working out a purposeful and sound decision under these conditions necessitate the automating of mental operations of an evaluation or calculation nature and requiring methodical work in a calm situation. On the other hand the ensuing problem of social responsibility of the commander and control bodies and the complexity of the mental problems being solved, place certain constraints on the process of automation. The taking of a decision to a definite degree always remains an area of creativity and art requiring an interaction of mind and will, logic and intuition, strict calculation and risk.

Another specific feature of military control systems is their high internal and external dynamicness. No other social control system possesses such flexibility, mobility and monolithicness as a troop control system. This

particular feature of military systems was pointed out by V. I. Lenin. "Let us take a modern army," he wrote. "Here is one of the best examples of organization. And this organization is good only because it is flexible, being able at the same time to impose a single will on millions of people."[3]

By internal dynamicness one understands the mobility and variability of the specific SUV structures. This particular feature is determined by a number of circumstances. In the first place, the organization of the subunits, units and formations of the armed forces is changed periodically. The structure is brought into accord with the developing weapons, military equipment, with the new methods of using them and with the new views on military art. Secondly, an organization used at a given moment is changed in the course of combat--and in a rather broad range--in accord to the set combat mission by the varying organization of the battle formation, by changing the number of attached (supporting) means, by organizing temporary groups such as forward detachments, vanguards, artillery groups, and so forth. Under various conditions the same control body can unite the actions of a varying number of controlled objects. The problem of control can be effectively solved only by a system which possesses the necessary structural flexibility and can easily reorganize itself for various specific variations of the organization of control.

The external dynamicness of SUV is manifested in the fact that its tactical and operational elements possess high mibility and maneuverability caused by the nature of modern combined arms combat (operation) and by the new means of locomotion. Certainly in solving the problems of automation, the given circumstance is the determining one, for the control systems which are unable to reflect and embody such dynamicness, that is, those which do not possess sufficiently portable and mobile equipment, cannot effectively carry out their missions.

The conditions of armed combat, the opposition of the enemy, the use of powerful weapons, and the high dynamicness of combat place increased demands on the SUV. In our opinion, the most important of them are the following:

1) Constant combat readiness of the control systems which is equal to the readiness of the troops themselves and making it possible to engage in action in the event of the outbreak of war;

2) The reliability (survivability) of the systems in work, the ability to provide continuous troop control under any conditions of a situation, including the launching of nuclear strikes by the enemy against its elements, in creating strong jamming by the enemy, with a shortage of initial data, as well as with great physical stresses;

3) Efficiency in work providing the prompt carrying out of control tasks;

4) The conformity of the control system's structure to the organizational structure of the troops, to the weapons, to the nature of combat and the existing technical control devices;

5) The mobility of control systems conforming to the mobility of the troops, the ability of the control bodies to rapidly shift their positions, and to control troops in motion;

6) Universality in organization and flexibility in action making it possible, without complex reorganizations, to control the troops under changing conditions, in various types of combat (offensive, defensive and so forth) carried out with the use of any weapons;

7) Concealment in work ensuring that the contents of the information circulating in the system and the locations of the SUV elements are kept secret from the enemy.

Moreover it is important that the control systems be comparatively simple and not too expensive. It is rather difficult to reconcile all of this in an ideal manner and obviously there is no such single universal means by which the carrying out of all the listed requirements could be ensured.

Automation is also no such universal means. Under the conditions of the dialectical development of military affairs, a portion of the mentioned requirements can be carried out only by full automation of the control processes. However, for carrying out another portion of the requirments, it is essential to combine automation with other measures. These are: the correct choice of personnel, thorough ideological-political, special military and moral-psychological training of the personnel of the control bodies; improving the structure and methods of work of the control bodies; diverse mechanization and technologization of the control labor, the further development of communications equipment, scientific organization of labor; improving the command posts and the correct combination of man and equipment.

The particular features of the SUV are clearly apparent in their unique internal structure and in the different relationships of subordination and coordination between the interrelated elements of the SUV. Certainly the structure of the control systems in the armies of various states has its specific features. It manifests the different and even directly opposing class-political, economic, national and other relationships. Within the armed forces of one country it is possible to detect specific features in the organization of the control systems in the various services of the armed forces and branches of forces, since they differ in terms of organization, technical equipping, and means of action. However, in all the SUV there are also common elements, the elucidation of which in methodological terms will help to solve the problems of automation. As the basic object let us take the control system which exists in the ground forces of a majority of modern armies.

The hierarchy of control systems which has been widely developed in them makes it possible to establish an order of subordination of the inferior control bodies and officials to the superior ones. Thus in the present-day organization of many armies these are: the soldier--squad (crew)--platoon--

company (battery)--battalion--regiment--formation--field force--ground forces as a whole.

The two adjacent intermediate levels (for example, platoon--squad, company--platoon) form a closed control circuit which is a subsystem in the broader system of control (in the first instance, in the company, and in the second, in the battalion). A number of control circuits corresponding to the number of subordinate units is formed by the control body of each element.

As a consequence of the division of functions and combat missions between the elements and subsystems of control, they are interconnected. On the level of coordination these are links of interaction. They do not correspond to classical control circuits, since there are not relations of subordination between the adjacent units, the various echelons and the basic and supporting means. However, between them communications channels are established and over these there is reciprocal information on the combat situation and their actions. A circuit of interaction when necessary can be turned (under combat conditions such a possibility is envisaged) into one of the control circuits.

The initial element of the troop control system is the serviceman (soldier, sergeant or officer) who controls the weapon, technical device or machine. He sees to the work of the mechanisms, he fires, he controls the movement of the weapons and equipment, he deploys them in a battle situation and strikes them in a march formation, he provides camouflage, and so forth. Here control can be carried out manually, semiautomatically or automatically.

In more complicated "man--weapons" and "man--machine" systems, control is carried out by a collective or persons, a crew, team or group of operators. In such systems, as in a primary tactical subunit (rifle squad), the problem arises of controlling the coordinated actions of the men, that is a specific feature arises which is characteristic for the SUV. A control circuit is created which includes the commander and subordinates linked by visual, sound or radio and telephone direct and feedback channels.

Such a control system is part of the superior subunit, the platoon, the wing of aircraft and so forth. Here the control function is also exercised by the commander, but his controlling effect is focused directly not on the soldier (the operators) armed with weapons and equipment, but rather at the persons whose specific duty is the control of persons, that is, the commanders of the squads (crews or teams). For the platoon commander they are the immediate objects of control. The "commander--subordinate soldiers" link even more clearly expresses the specific features of the troop control systems. For fully describing its particular features just one element is lacking, the group control body, the staff, which arises and is developed in the last stages of the hierarchical ladder.

The last, evermore complicated control elements are: company--platoon (and the subunits corresponding to them); battalion--company; regiment--battalion, and so forth. The structure of these subsystems and elements has a number of particular features.

In a majority of modern armies, starting from such subunits as the company and the battalion, the commander leads the subordinate troops not only personally but also with the help of specially created command bodies and various equipment. Thus, in the U.S. Army, the company commander already has a command section consisting of an assistant company commander, a supply sergeant with an assistant, a communications sergeant, a company clerk and three radiotelephone operators. In addition to the commander, the control system of a battalion in the U.S. Army also includes such a body as a staff consisting of a chief of staff and officers for personnel, reconnaissance, operational questions and military training, for the rear and communications, as well as a chemical officer, and others. For creating direct and feedback channels as well as for other support functions on the staff company of a battalion, there are special subunits (a section for staff and ground observation, a signals platoon, reconnaissance platoon, and others).

Starting from the regiment, the basic command body is considered to be the combined arms staff which has a rather complicated structure and under the leadership of the commander carries out the entire aggregate of command and control measures. The combined arms staffs usually consist of officials or of departments (sections) created by the principle of the specialization of labor and division of functions. For example, on a majority of the formation and field force staffs of modern armies in the capitalist states, there are such divisions and departments as reconnaissance, operations, personnel, communications, administrative, and so forth. Moreover, on these levels there are also the chiefs of the corresponding branches of forces, special troops and services who are responsible for the state and correct use of the subunits and units of their own branch of forces, and they ensure concrete and skilled leadership of them.

Ordinarily they exercise control and command through their subordinate officers, sergeants and soldiers. Some of the chiefs of the branches of forces can have their own staffs. The hierarchical ladder in this manner is developed not only along the vertical but also along the horizontal, forming additional control subsystems for the branches of forces and special troops.

In solving automation problems, consideration is given to the principles which underlie the structure and functioning of SUV. The most important of them are unity of command and centralization.

The principle of unity of command is a basic one in the organizational development of the armed forces and in the command of troops in peacetime and wartime. Its essence consists in the concentrating of all power in the hands of one individual who takes the decisions and bears personal responsibility for the combat readiness of the subordinate troops and for their

successful execution of combat missions. The commander (troop commander) is this person in each control element.

V. I. Lenin repeatedly pointed to the objective necessity of unity of command in controlling large industrial and technical complexes. "No railroads, nor transport, nor large machines and enterprises," he wrote, "can function correctly at all if there is no unity of will which links all the available workers into a single economic organ working with the exactness of a clock mechanism."[4] V. I. Lenin considered the observance of this principle particularly important in the organizational development of the armed forces and in troop control. "Irresponsibility covered up by references to collectivism," he stressed, "is the most dangerous evil which...in military affairs leads constantly to catastrophe, chaos, panic, divided rule and defeat."[5]

The principle of unity of command has an opposite class-political nature, content and focus in the armed forces of the imperialist and socialist states. In bourgeois armies this expresses relationships of social inequality, exploitation and suppression, and serves the reactionary and aggressive aspirations of monopolistic groupings. In the socialist armies it embodies the moral and political unity and cooperation of the working classes and is aimed at achieving just, progressive aims. In the USSR Armed Forces unity of command is exercised on a party base and presupposes the high political awareness of each officer, his constant execution of the policy of the Communist Party and the Soviet government, and a reliance on the party organizations in carrying out specific missions.

The principle of unity of command in no way means that the commander can ignore the results of work or the opinion of the collective of a control body. Such a practice would cause harm and would lead to subjectivism and an abuse of power. Truly scientific leadership consists in the skillful combination of strictest unity of command in taking a decision and carrying it out with the fullest utilization of the experience, initiative and creativity of the officers of the control body (in operational elements, persons who are a member of the military council), the party and Komsomol organizations and all the personnel.

Under the conditions of a further differentiation in the functions of the officers of control bodies it is particularly important that the commander correctly use the knowledge and experience of the specialists and the opinion of the chiefs of the branches of forces, the officers of the corresponding departments and services. V. I. Lenin cautioned leaders: "Really isn't it shameful to correct offhandedly the work of hundreds of the best specialists, to resort to noisy jokes and to boast of one's right 'not to approve'?"[6]

The instructions of V. I. Lenin have maintained their timeliness even now. They focus on the correct use of collective reason in working out and establishing decisions and in planning combat.

The principle of unity of command is supplemented and organizationally supported by the principle of the centralization of leadership. Its essence consists in the consistent and strict subordination of the inferior levels to the superior ones, and in the unifying of the actions of subordinate troops according to a single plan for achieving the overall goal of combat (an operation).

This principle also requires skillful and flexible application, and in particular, an understanding that centralization under certain conditions of modern armed combat can be combined with decentralization of control, and include the latter as a particular aspect. This means that in special circumstances the independence of certain units and formations can rise, particularly when they operate away from the remaining troops, in the absence of contact with a senior chief, as well as with acutely limited time for preparing combat. It is also essential to bear in mind that too rigid centralization can lead to an informational overloading of the superior levels and to the thwarting of the initiative and creativity of subordinates. Excessive interference has a harmful psychological effect. It teaches the subordinates to wait in all instances for instructions from a senior chief. In emphasizing the danger of these tendencies, L. I. Brezhnev formulated the following demand: "...A very important element in improving economic leadership is an improving in the organizational structure and methods of management. We must simultaneously strengthen both principles of democratic centralism. On the one hand, it is essential to develop centralism thereby creating an obstacle for departmental and local trends. On the other, it is essential to develop the democratic principles, initiative on the spot, to free the upper leadership echelons of unimportant matters, and ensure efficiency and flexibility in decision taking."[7]

The principles of centralism and unity of command have been considered in working out the overall structure of the ASUV, in disclosing the links between its elements, in determining the control functions which can be automated, the degree of automation of the hierarchically linked elements of the control system, in establishing the nature and volume of information re ceived by each control element, and so forth.

The solving of automation problems is also influenced by the specific features of organizing command posts. They can be stationary or mobile, located on armored personnel carriers, motor vehicles, airplanes, helicopters and ships.

For ensuring the survival and continuous operation under conditions of modern war, in foreign armies, in each element of the control system several command posts are organized and these are capable of taking over for one another in the event of the knocking out of one of them. One of these posts is the basic one. For example, in the U.S. and West German divisions, corps and armies, a basic command post is created along with a reserve or forward of rear command post. In addition, for the same purpose provision is made for the shifting of control in the event of the knocking out of the basic and

reserve command posts to the command posts of the chiefs and subordinate commanders of the formations.

For ensuring the work of the command posts and for maintaining uninterrupted communications, the control bodies have at their disposal the corresponding equipment for reconnaissance, communications, as well as for collecting, processing and displaying information.

In all armies basic attention is given to developing such an element of the control systems as the direct and feedback channels between the control bodies and the controlled objects. Here an effort is made to ensure their uninterrupted work considering the requirements of reliability of operation with the necessary range and capacity, accuracy, speed and secrecy in transmitting information and sufficient resistance to jamming.

For meeting these requirements, it has been recommended that various types and methods of communications be used together, including: radio, radio relay, wire, telegraph with letter printing, signal, high speed, and so forth. In the opinion of foreign specialists, the recent achievements of science and technology in the near future will make it possible to supply the control bodies with fundamentally new equipment.

This generally is a description of modern troop control systems, their nature and purpose, the structure and functions, the design principles and the operating conditions. From this total evaluation it is possible to draw the following tentative conclusions on the automation of SUV. In the first place, the very conditions and particular features of its functioning predetermine the further development and deepening of full automation of troop control processes. Secondly, the socioclass nature, the complexity, multiplicity, and dynamicness of the SUV not only give rise to difficulties on this path, but also impose definite limitations on the process of automation, and demand that it be combined with other directions for improving the troop control systems and methods.

The concretization of this conclusion and a clarification of the possibilities, ways, stages and depth of the automating of control require a more detailed examination of the very process of troop control, as well as its essence and content.

2. Modern Views on the Essence and Content of the Troop Control Process

The content of control in its cybernetic understanding was briefly examined in the first section of the current chapter. In starting from this general description, it is essential to bring out the specific features inherent to the processes of troop control and thereby create additional prerequisites for the specific conclusions on the fundamental and real opportunities for automating control.

For solving this problem, a mere cybernetic description of the elements in the informational cycle of control is not sufficient. There must be a thorough evaluation of the content of the troop control process considering its aims, means and the sequence of stages. Going beyond the confines of the informational aspect of the review makes it possible to consider the sociopolitical, the military-technical, moral-psychological and logical-gnoseological aspects of the troop control process.

A correct definition of the essence of troop control is not a simple matter. As an example, several definitions can be given. One of them, for example, states: "Troop control (the control of combat and an operation) is the preparation, conduct and support of the combat by the commander with the aid of the staff and other command bodies."[8] But combat is not directly carried out by the commander or the staff but rather by the troops they control.

Another well known definition is also not without shortcomings. It states: "Troop control is constant leadership by the commanders and staffs of all levels over the activities of the subordinate troops (aviation or navy) and aimed at carrying out the set missions."[9] Here there is indication of a definite purposefulness in the control process, however its content is transmitted by the words "constant leadership." The reasonable question arises: what must be understood as leadership? Are not the concepts of "leadership" and "control" identical? If this is the case, then the definition will be logically incorrect.

In our view, basic attention should be focused not on a comparison and criticism of the various definitions, but rather on examining and describing the very process of troop control. For this purpose it is essential to isolate the control activities from the general activities of the troops. As is known the latter are permeated by control, they comprise the basic spheres of its application, and characterize the types of control problems. Nevertheless, control does not coincide with all troop activities, it does not exhaust them, but rather comprises its inner core, it systematizes and links these activities into a single whole.

Control is an active process, and it always in one way or another invades a natural or spontaneous course of things. Its primary aim is to maintain a given system, its integrity and the capacity to function. However, under the constant changing conditions of the environment it is impossible to maintain the system without altering its structure and functions within certain limits. And these changes should not reduce but rather increase the efficient functioning of the system and its interaction with the environment. A correspondingly secondary and more profound aim of control is to improve the system and to ensure the development of its structure and functions.

Proceeding from this overall description of the essence of control, it can be asserted that the sense and aim of troop control consists in those changes of their organizational structure, state, battle formations and methods of combat which provide for the maintaining and improvement of their

combat capability and readiness, and the carrying out of the combat missions (the defeat of the enemy) in the shortest time and with the least losses and material expenditures. Thus, the preparation, execution and support of combat in their aggregate comprise the sphere of control. Control itself consists in optimizing these processes, directing the efforts of the troops at carrying out the corresponding missions, coordinating their actions and giving them purposefulness, planning and organization.

In its content, troop control includes a significant number of measures and forms of activity which differ in their nature. If it is viewed in the various stages of troop activities, then it is possible to isolate the preparation of troop combat and troop leadership in the course of combat. With such a division the measures to support combat are not isolated in a separate group, for they are part of the content of both the first and second stage. The latter also are not always completely separated from one another. In contrast to the past, under present-day conditions the troops which carry out a previously received mission can simultaneously prepare to carry out a new mission, since there will be no long pauses between periods of combat. However, for analyzing the content of the troop control process, the division made is completely acceptable and advisable.

During the period of preparing for combat, the commanders, the staffs, the chiefs of the branches of troops (services) and the party political apparatus[10] carry out measures aimed at implementing the following missions: Maintaining constant combat readiness, including a high political and moral state of the troops; the collecting and evaluating of situation data, the taking of decisions and planning of combat; the issuing of missions to the troops and the organizing of their cooperation; the military and political preparing of the personnel to carry out the forthcoming combat mission; the organizing of all-round support for combat and the control process itself; inspection of the readiness of the units and subunits to carry out their missions with the providing of the necessary help for them.

The core of all this work is the maintaining of constant combat readiness of the troops. This is the most important task of the commanders and control bodies of all levels both in peacetime and in wartime. The level of troop combat readiness is the basic criterion for the efficiency of control in each of the designated periods.

High combat readiness under present-day conditions is a very vast concept. It cannot be reduced merely to the rapid assembly of troops upon a combat alert, although this is an important indicator. As Mar SU A. A. Grechko has written, combat readiness "is that state of the Armed Forces whereby they are ready at any moment and under the most difficult conditions to repel and stop aggression, from wherever it might arise and whatever means and methods be used, including nuclear weapons."[11]

The second group is made up of the measures for troop leadership in the course of combat. In terms of their general content, at first glance they may appear little different from the measures related to the preparation of

combat. Certainly in the course of combat, for example, the task of maintaining readiness of the troop and their high political and moral state remains in force. Only here its fulfillment will be related primarily to protecting the troops from mass losses and to restoring their combat capability in the event the enemy uses weapons of mass destruction. The necessity also remains of the all-round support of combat. Only here great flexibility and mobility are required in implementing the corresponding measures.

The basic content of the control process in the course of combat is made up of: The continuous collection and study of current data on the changing situation; the taking of particular decisions which ensure the fulfillment or adjustment and even fundamental alteration of a previously taken general decision; the posing of new (adjusted) missions for subordinate troops and the maintaining of their cooperation; supervision over the course of combat and the fulfillment of the given missions by the troops.

A general description of the essence and purpose of troop control as well as the list of the basic measures comprising the content of the control process in the period of preparing the troops for combat and in the course of it make it possible to provide the following definition. Troop control is the activities of commanders and control bodies based on objective laws and principles of military art and aimed at maintaining the high combat readiness of the troops and directing their efforts at the successful execution of the combat mission in the course of combat. The process of troop control is carried out by the continuous securing and evaluation of situational data, the taking of decisions, the issuing of tasks to executors, and all-round organization and control of their fulfillment.

The given approach corresponds to the cybernetic understanding of control, and at the same time makes it possible rather fully to reflect the specifics of troop control. Here we have defined: who, on the basis of what and for what purpose exercises control of whom. At the same time, the specific content of the control process, its elements and sequence of actions are disclosed and these form a closed and constantly renewed cycle.

Before describing the other aspects of the control process, it is essential to mention the basic demands made on it and which stem from the particular conditions of the functioning of troop control systems. Among them we must mention first of all the firmness of control, that is, the ability of the commanders and control bodies to constantly carry out the taken decision, to retain in their hands the leadership of men in a difficult situation, to prevent panic and a mood of doom when being exposed to weapons of mass destruction, to restore the battleworthiness of the troops and ensure the carrying out of the combat mission.

Another demand is the flexibility of control, that is, a rapid response to a change in the situation, a prompt adjustment, and when necessary, a fundamental change in the taken decisions, the elaborated combat plan and the very system of control.

The great dynamicness of modern combat places on control the demand of high efficiency, speed in implementing each element of the control cycle and in solving control problems as a whole. The basic criterion of efficiency is the time spent by the commander and the staff on the collection and processing of situational data, on the taking of a sound decision and the issuing of assignments to executors. This time should make it possible to anticipate the enemy in making the strike.

In the course of modern combat, more complicated conditions arise for carrying out such requirements as continuity and secrecy of control, the ability to maintain uninterrupted contact with the troops, and to keep the plan of one's actions and the order of carrying them out a secret from the enemy. The particular urgency of this requirement is caused by the increased ability of the enemy to reconnoiter and destroy our command posts using nuclear strikes, to disrupt communications by jamming, as well as increase the distances between command posts and their extended remaining in motion.

An elucidation of the tasks and measures related to troop control in the preparatory stages and in the course of combat is also needed for a correct approach to the problem of the automation of control. However, such analysis is not sufficient for solving this problem. It does not make it possible to clearly isolate the forms of control activity which to a varying degree require and allow their automation. For this reason, for a further analysis of the content of the control process there must be a different basis for isolating and describing its certain aspects and sides.

Such a basis can be the difference in the material (practical) and ideal (mental or creative) activity of people. It is essential to bear in mind that this difference is absolute only in the gnoseological term. Certainly the practical actions of people are also permeated with awareness, and mental activity occurs on the basis of practice and at each step is checked by it. Nevertheless, such a division is objectively caused and is methodologically justified.

Proceeding from the accepted basis, it is possible to break down the control process having isolated the two forms (types) of activity inherent to the solving of any control problem.

One type (form) of activity is comprised of ideal, mental activity, related to the understanding of the combat situation, the taking of a decision and the planning of combat. This makes it possible to define it as a cognitive planning activity of the commanders and control bodies. This comprises an inseparable element of any control process and itself consists of a number of particular components.

Its initial base is the process of cognition as a reflection of objective reality in the conscience of people. The elements of the cognitive activity of a commander are: The obtaining of initial data on the combat situation and the combat mission from a senior chief; elucidating the received combat mission; acquiring additional (lacking) data on the situation, their

generalization and depiction on charts, in documents and so forth; analysis and synthesis of the obtained data on empirical and theoretical levels, that is, a thorough evaluation of the situation.

The other part of this activity discloses the constructive and creative abilities of our thinking which introduces into reality something unique and not having a direct prototype. The basic sphere of the productive thinking of the commander is the elaboration of a decision, above all the formulating of the aim and plan of the forthcoming battle (operation) and its thorough and detailed planning. This activity is similar to scientific discoveries, invention and designing. It includes aspects of intuition, reliance on acquired experience and the use of the most recent scientific planning methods, including mathematical modeling of combat and the utilization of computers and network schedules.

The particular features of the constructive and creative thinking of a commander have been aptly described by Gen P. I. Batov: "Like any creation of the hands and will of people, combat is carried out twice--initially in thought and later in reality. If the chief of staff is the mathematician of the operation, this is not enough for the commander. He should by the strength of imagination, in focusing his foresight, live through this first, mental battle the details of which are imprinted in one's memory like frames on a film."[12] This description is presently being complemented by new aspects related to the constructing of special mathematicological models of combat and the use of the mathematical methods of operations research and computers in the process of planning them.

Cognition and planning are two organically related processes. They accompany one another in all stages of solving control problems. Thus the obtaining and elucidation of a combat mission are accompanied by the tentative formulation of one's own mission and plan for the forthcoming actions. This aim directs the further process of securing information on the situation, as well as the grouping and generalization of information. In turn, such work makes it possible to clarify the initial plan and in general terms outline the decision for combat (an operation). From the viewpoint of the adjusted plan and a sketch of the decision, an empirical and theoretical analysis of the situation, its thorough evaluation and the elaboration of a final decision are carried out. But from the very moment of formulating the initial combat plan, the planning of combat also starts. In planning a detailed program of troop operations to carry out the set decision is developed and established step by step from the general aims.

This is a general description of the cognitive and planning activities of the commanders and control bodies. On the basis of them another form (type) of control activity is carried out and this could be termed the practical organizational activities of the commanders and control bodies. This includes a number of measures aimed at implementing the taken decision. They include: The giving of missions to the troops, the organization of their cooperation and support, the carrying out of the necessary political work, and the overseeing of the readiness of the troops and their fulfillment of the given missions.

In the practical and organizational activities of the commanders and control bodies one can also isolate two aspects. The first involves the special military or technical aspect and encompasses the carrying out of a multiplicity of tasks, starting from the staffing of the combat units, the assigning of personnel to them and ending with the all-round support of combat. The range of these activities includes all questions related to the organization of combat.

The other aspect is related to controlling the spiritual forces of the men, to the ideological and psychological preparation of the personnel to carry out the combat missions, and to maintaining a high political and moral state of the troops in the course of combat. Even V. I. Lenin pointed to the importance and necessity of stressing this aspect. "In any war," he stressed, "victory ultimately is determined by the morale of those masters who shed their blood on the battlefield."[13] Military historical experience indicates that it is possible to take a correct decision to prepare for its practical implementation properly in special military terms, but nevertheless be defeated if the personnel is not properly prepared in ideological and moral-psychological terms.

In describing the problem of the style of leadership, L. I. Brezhnev in the Accountability Report to the 25th Party Congress noted: "A modern leader should organically combine party loyalty with profound competence, discipline with initiative and a creative approach to the job. At the same time, in any area a leader must also consider the sociopolitical and indoctrinational aspects, he must be sensitive to other people, to their needs and requests, and serve as an example in work and everyday life."[14] The given statement applies fully to the sphere of troop control. Organizational and indoctrinational work is an inseparable element of control. In relying on the party and Komsomol organizations, this is carried out by the commanders, the political bodies and all the officers. In structural terms it is formed from the aggregate of the constantly carried out measures to maintain a high political and moral state and a complex of measures related to the special training of the personnel in line with a specific combat mission.

The cognitive-planning and practical organizational activities are closely interrelated. Cognition and planning in various forms permeate all practical and organizational activities. In turn, they themselves need a definite organization and practical actions. However, the distinguishing of these forms of activity reflects one of the real cross-sections of the control process; it is particularly important for evaluating the possibilities of automation.

The cognitive planning and practical organizational activities in control to a varying degree require and permit automation. And to a varying degree the individual elements of these activities are automatable: cognition of the existing situation, the taking of a decision and planning future actions as a whole; the carrying out of measures of a special military nature and the ideological and psychological preparation of the personnel. This

is seen from a general comparison of them, but an analysis of the content of each particular element of troop control gives even greater convincingness to this conclusion.

For describing the cognitive activities of a commander it is important to define their initial moment. In each specific instance the receiving of the initial data and the combat mission from the senior chief can be considered as this. This is a powerful impetus for activating the process of studying the situation. However its cognition actually begins before this moment. The collecting of data on the situation is an uninterrupted process, and the commander usually possesses a certain supply of information on it even before the receiving of the combat mission. This information has been acquired in preceding combat, in the process of the preliminary study of the enemy and the terrain, and so forth. Moreover the cognition of the situation starts even in the course of the general theoretical and practical training of command personnel. The knowledge acquired by them represents an unique information model of armed combat in the given theater of operations. It also acts as the most general initial aspect in understanding the actual combat situation, in logically directing the elucidation of the mission, the collecting of lacking information on the combat situation, a thorough evaluation, the forming of a plan for forthcoming combat (an operation), the taking of a decision and the planning of combat as a whole.

It is important to consider all of this in defining the possibilities, tasks and limits of automating the process of cognition and planning. The potential objects of automation in one way or another are the following: The three designated initial aspects--the general (the information model of armed combat), the particular (the preliminary store of information on the situation) and the specific (the mission and the initial data obtained from the senior chief), as well as those elements from which the subsequent cognitive and planning activities are formed. Let us briefly examine their content.

The obtaining and analysis of the combat mission are a cognitive process in which the commander receives and assimilates information on the state and trends in the change of the situation on the scale of the superior level; on the plan of the superior chief, his intentions to use weapons and particularly nuclear weapons; on the procedure and order of combat; on the role assigned to his unit or subunit and the given combat missions. Here the brain of the commander performs in no way passive functions of a receiver or a living display device. His mental work does not have a formal logical nature. Even in this stage there begins the countermovement of the commander's thought, the shaping of his own plan and an understanding of the essence of the pending combat which is possible only on the basis of dialectical thought.

The collection of lacking information on the actual situation existing at the moment of receiving the combat mission is an objectively necessary condition for the working out of a sound decision by the commander. This element in cognitive activity encompasses not only the securing of

information but also its transmission over the communications channels to the superior control bodies and the required transformation, generalization and systematization of military information and the display of the obtained information using sign systems (documents and charts) as well as special equipment (screens, boards and so forth).

The commander and the control bodies study the following elements of the situation: The enemy, their own troops, adjacent units, the terrain, the radiation, chemical and biological situation, the hydrometeorological conditions, the season and the time of day, as well as the economic condition of the combat area, the socioclass composition of the population and its attitude toward our troops. The volume and content of information on each of these situation elements will differ depending upon the type of combat, the nature of the obtained combat mission and the objective conditions for securing this information. We would point out that some of them depend upon the decision and actions of the commander in the preparatory period (the position and moving of his troops, their political and moral condition, material-technical and other supply). But other indicators (the enemy grouping, the position of adjacent units, the nature of the terrain, and so forth) before the start of combat do not depend upon the decision taken by the commander.

All the designated processes require significant outlays of labor and time. Certainly many operations which are carried out here are repeated, they are standard and contain more formal than creative aspects. For this reason here there is a significant area for technologization and automation.

The evaluation of the situation and a thorough analysis of the information obtained on its elements comprise the cognitive foundation of the commander's decision.

The essence of this work consists in the fact that the commander reasons out the conditions for carrying out the combat mission and the factors which determine the possible development of combat and thereby influence the nature of the decision to be taken.

Here the shaping of the plan of action can occur predominantly by analytical means with the subsequent reasoning out of each element in the situation. In other instances a generalized synthetic approach can prevail when a series of elements in the situation or even all of them are considered simultaneously from the viewpoint of their influence on selecting the direction of the main strike, on determining the battle formation of the troops, on the distribution of combat missions between them, and so forth. Such an approach is particularly effective when the commander possesses great experience, he knows the changes in the situation even before receiving the mission, and possesses limited time for working out a decision.

The overall evaluation of the situation is made by the commander and the chief of staff who always should be ready to report their conclusions on any element and on the situation as a whole. The remaining staff officers

and the chiefs of the branches of forces (services) evaluate the situation from the viewpoint of carrying out their own functional duties.

The evaluation of a situation is a complicated creative process. It is difficult to formalize it completely. It includes not only the logical procedures of thought (analysis and synthesis, induction and deduction, abstraction and generalization, and so forth) in their dialectical unity, but also imagination and creative intuition. Since the commander evaluates the elements of the situation in their unity and reciprocal influence from the viewpoint of the conclusions made by him in analyzing the combat mission, the same factors of the situation can be given a differing evaluation in a different context. Moreover, some data can be incomplete, fragmentary, accidental or even false and fabricated by the enemy. For this reason it is essential to fill in the missing elements, to synthesize the contradictory aspects, to weed out false ones, and so forth.

Moreover, in evaluating the situation a commander is forced to consider many factors which at times go beyond the limits of the immediately arising combat mission. He proceeds from the general political situation, and considers the effect both on our troops and on the enemy troops of the sociopolitical factor, economic conditions, ideological phenomena, the individual and social psychology of people, and the social consequences of the forthcoming combat (operation).

The dialectical nature of the evaluation process does not exclude uniform and repeating formal logic operations. The preliminary material for a thorough evaluation of the situation can often be obtained by formal and relatively independent qualitative and quantitative comparisons for certain parameters. The answers to the questions of who, where, when, how much, what balance of forces, and what is the radiation level? and the logical conclusions from them must be considered under any circumstances. The analysis of such parameters and the elaboration of the criteria and algorithms for evaluating them can become a basis for automating certain operations related to an analysis and evaluation of the situation.

The choice of the most effective and sound variation of a decision and the planning of combat comprise the concluding, most complicated and responsible stage in the work of the commander and the staff.

Since all the measures related to the control and actions of one's troops are carried out in strict accord with the decision made by the commander, this is rightly considered the basis of the entire control process. The chief's decision determines the aim of the actions, the forces, means, methods and times of achieving it. It becomes the basis and a component part of the entire process of planning combat. Certainly the aim of planning consists in seeking out the best ways for carrying out the combat mission. Its content includes a determining of the sequence, times and methods for the troops to carry out the received mission considering the expected results of the use of weapons, the establishing of a firm order

of cooperation between the troops in terms of the target (objectives), the time and place, as well as the organizing of all-round support for combat and troop control. But precisely these questions are reflected primarily in the commander's decision, and for this reason it is also the basis of planning. In accord with the commander's decision and under his personal leadership, the staff and the chiefs of the branches of forces (services) detail and concretize the individual questions of organizing combat, they seek out the optimum variations and methods for carrying out the combat mission and back them up with the needed calculations. The results of the planning work are usually given a graphic depiction on maps, as a brief explanatory note and in other documents.

In their aggregate decision taking and the planning of combat are a creative process in which the cognitive and constructive activities of man are closely intertwined with his volitional efforts, and they require not only knowledge, reason, developed intuition, imagination and military guile, but also courage, boldness and the readiness to assume the entire burden of responsibility.

In the aim of achieving surprise, a commander may consciously take a risk and make a decision which mathematically cannot always be backed up. This particularly applies to selecting the direction of the main strike, the forms of maneuver, the time of actions and so forth. Such decisions are often taken seemingly against the demands of the objective conditions and established views. This is done counting on the fact that the actions of our troops would be a surprise for the enemy. The characteristic historical examples of such "illogical" actions were the choosing of the direction of the main thrust of our troops in the Belorussian Operation, the nighttime attack on the defenses of the Nazi troops in the Berlin Operation, and so forth. All of them were marked by surprise and high combat effectiveness.

The creative nature of the process of decision taking and planning of combat does not exclude the possibility of automating them. The constructing of the elements of the decision and the plan in several variations and a comparison of them in the present stage of scientific development can fully be an object of algorithmization, planning, and consequently, automation. There are particularly broad opportunities for this in carrying out various calculations and playing through (varifying) the mathematical models of forthcoming actions or certain episodes of them on a computer.

From the viewpoint of automation let us examine the practical organizational activities of the commander and control bodies. These begin by the issuing of combat missions to subordinates, by instructions on cooperation and the support of troop combat. The transmission of the corresponding information can be carried out by the commander, through the staff officers, in writing and using equipment and communications.

We must particularly take up the issuing of missions to subordinates with personal contact between them and the commander and staff officers. The practice of wars has showed the exceptional importance of this. No equipment

can replace the vital word of a commander. On the spot he is able to make certain that his subordinates correctly understand the combat mission, he can have the necessary moral and psychological impact on them, instill confidence in victory and inspire them to a feat.

The basic criteria in selecting one or another method of issuing a combat order are speed, concealment and accuracy. In all instances the subordinate officer should receive a mission within a time which would allow him to prepare the personnel and the equipment for combat and anticipate the enemy in making the strike. Even before taking a decision the commander gives preliminary orders, and informs his subordinates of the forthcoming actions and the procedure for preparing for them in parallel with the superior level.

The issuing of a decision to the executors is merely the start of the practical organizational activities of control. One of its important elements is the manning and arming of the troops with personnel, weapons and equipment, the strengthening of command personnel, and the uniting and rallying of the units and subunits. Of course, these questions are solved continuously even before the giving of the combat mission. However, such work is carried out right until the start of combat, and sometimes these measures can become necessary and possible precisely with the obtaining of the combat mission in line with its special nature and importance.

Troop leadership includes the organizing and maintaining of cooperation and these are carried out by the commander and the staff during all of combat. Here special attention is given to coordinating the actions of the troops to effectively use weapons of mass destruction, air strikes and artillery fire.

An important area of control is the organization of the all-round support of troop combat. Usually the following basic types of support for troop combat are distinguished: Reconnaissance, protection against nuclear weapons, radioelectronic countermeasures, camouflage, security, engineer, rear (material, technical and medical), topogeodetic and hydrometeorological support and the organization of the commandant service.

In solving problems related to the organization of all-round support, the commander gives particular attention to the key questions. The details of this work are planned and organized by the staff, the deputy commanders and the corresponding chiefs of the branches of forces and services.

A number of practical measures relates to the organization of the very control process. The commander, the chief of staff, the chiefs of the branches of forces (services) and the chiefs of departments set up, disassemble and move the command posts, they coordinate their work and provide continuous communications with the troops, and they organize and ensure the smooth work of the control bodies. The demands placed upon control as a whole will be carried out to the degree to which the work of the control bodies has been organized.

Finally, among the measures of a practical organizational nature are the supervising of preparations to carry out a combat mission and the course of its fulfillment. The given element completes the control cycle in solving any problem. In exercising supervision, the commanders and the officers of the control bodies study the state of affairs in the troops, they given instructions to eliminate the detected shortcomings, and provide the needed help for subordinates. Here also an important role is played by the direct contact of the commanders and the officers of the control bodies with subordinates. This is a general estimate of the special, military-technical aspect of the practical organizational activities of control.

The following can be said on the ideological and psychological sphere. This includes the carrying out of a number of tasks and specific measures aimed at strengthening the morale of the personnel and their readiness to carry out the combat mission under difficult conditions.

The carrying out of these measures comprises the area of party political work which must be viewed as an essential and important element of control as a whole. Party political work in the troops is related to indoctrinating them in a spirit of total loyalty to the socialist motherland and to the cause of the Communist Party. In a combat situation this must ensure a profound understanding by the personnel of the policy of the party and the government, the aims and nature of the war, the tasks confronting the Armed Forces, and it must instill a loyalty of the men to the oath and high moral and psychological qualities. With the receiving of a specific combat mission, this work is aimed at a correct conception of the mission by each soldier, sergeant and officer, and at instilling in them combat drive, boldness and valor, and a feeling of collectivism and mutual help. These goals can be achieved only by the vital and creative activities of the commanders, the political workers, and all the officers of the control bodies, the party and Komsomol organizations directly in the troops, in the mass of soldiers.

Thus, in the general process of armed combat, along with the actions of the troops themselves, activities related to their control are also carried out. These are a goal-directed, creative process in which the cognitive planning and practical organizational work of the commanders and control bodies is inseparably linked. Its content is the complex of measures to prepare for battle (an operation) and to direct the efforts of the troops at carrying out the received combat mission in the course of combat. Among the multiplicity of measures, it is possible to isolate core and constantly repeating ones. These are related to the collection and studying of data on the situation, the taking of a decision, the issuing of orders to executors, the practical organization of their execution and overseeing the actions of subordinates.

Even a preliminary description of these shows that some of these measures require automation or have already been automated. At the same time one

cannot help but see that in the practical organizational activities, particularly in party political work, there must be a personal, vital contact of the commanders and political workers with the personnel. This must be considered in solving automation problems.

However, in order to draw a completely sound conclusion on this question, it is essential to examine in detail the potential and real possibilities of automating each of the designated elements of the control process, the principles for setting up ASUV, the real characteristics of modern ASUV and the potential opportunities of developing them in the future. The materials have been given using the views of specialists in foreign armies.

FOOTNOTES

1. See D. A. Ivanov, V. P. Savel'yev and P. V. Shemanskiy, "Osnovy Upravleniya Voyskami" [Principles of Troop Control], Moscow, 1971.

2. VOYENNO-ISTORICHESKIY ZHURNAL, No 2, 1962, p 73.

3. V. I. Lenin, "Poln. Sobr. Soch.," Vol 26, p 258.

4. Ibid., Vol 36, p 157.

5. Ibid., Vol 39, p 46.

6. Ibid., Vol 42, p 344.

7. "Materialy XXV S"yezda KPSS," p 60.

8. See "Malaya Sovetskaya Entsiklopediya" [Small Soviet Encyclopedia], Vol 9, Moscow, 1960, p 774.

9. See "Slovar' Osnovnykh Voyennykh Terminov" [Dictionary of Basic Military Terms], Moscow, 1965.

10. In the remaining text, instead of listing all the officials and bodies, the term "commander and control bodies" will be employed.

11. A. A. Grechko, "Vooruzhennyye Sily Sovetskogo Gosudarstva" [The Armed Forces of the Soviet State], Moscow, 1975, pp 110-111.

12. P. I Batov, "V Pokhodakh i Boyakh" [On Campaign and In Combat], Moscow, 1962, p 52.

13. V. I. Lenin, "Poln. Sobr. Soch.," Vol 41, p 121.

14. "Materialy SSV S"yezda KPSS," p 70.

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CHAPTER 3: POTENTIAL AND REAL POSSIBILITIES FOR AUTOMATING TROOP CONTROL

1. Structure, Functions and Principles of Creating Automated Troop Control Systems

The automating of troop control presupposes the integrated use of automated and automatic devices and systems, as well as modern scientific methods making it possible to sharply increase the efficiency of control in the aim of optimizing the use of the forces and means and freeing the commanders and staff officers from uncreative work.

Troop control is always carried out in a system which represents an aggregate of interrelated direct links and feedback between the controlling and controlled bodies with their command posts and technical equipping, and must provide the attaining of the goals posed for the troops or the carrying out of combat missions with the greatest efficiency.

By control bodies one understands a system of officials, the corresponding troop formations, the necessary materiel used in the interests of troop leadership.

Proceeding from this it can be considered that an automated troop control system (ASUV) represents an aggregate of interrelated control bodies (points) equipped with modern highly productive control equipment which ensures the optimum and intercoordinated use of the possibilities of man and the automatic devices in the aim of achieving maximum effectiveness of combat.

The ASUV can include subsystems for controlling subordinate troop formations with their weapons and equipment. Moreover, the ASUV and the subsystems comprising them can include as their elements automated and automatic weapons control systems.

Automated weapons control systems (ASUBS) are complexes of the "man--technical device--weapon" type which are used for achieving an optimum mode of action and the most effective use of the weapons and military equipment. Among them, for example, one could put the antitank guided missile units. The automatic control systems (SAU) consists of controlling

and controlled devices which operate in accord with a previously elaborated and set program, for example, the SAU of an antiaircraft missile complex.

The designated systems are set up considering the nature of armed combat, the organizational structure of the troops, the development level of the weapons and the technical control devices. The structure of the ASUV is a dialectical unity of staff organizational, functional and technical elements which ensure the effective execution of the given missions. The staff organizational elements of the structure are the hierarchical command elements. The functional elements are represented in the structure by clearly defined rights and duties of the officials, by the type and number of command posts, by the work methods of the commanders and staffs in the area of troop control. The diverse types of control equipment act as the technical elements.

Thus, the forces and means of control comprise the basis of the automated control systems. They can be divided into two basic groups: the control personnel and the control equipment.

The control personnel is the personnel of the control bodies (points), and above all the commanders and staff officers. The quality and level of control depends upon the level of their training, their creative approach to solving questions, firmness, courage and resourcefulness.

In the ASUV the following can be used as control equipment:

1) The equipment for securing and collecting information: aircraft, radios, radar and other reconnaissance equipment;

2) Machines which fix information: punches, typewriters, signaling equipment, tape recorders, dictaphones, as well as equipment for reproducing and copying documents;

3) Machines for data processing: electronic computers, keyed calculators and tabulators;

4) Equipment which converts information: readers and coders, devices for transcribing from puch cards to punch tape and back, microfilming and microfilm reading equipment;

5) Devices for putting out information: automatic printers and machines, electronic displays, screens and automatic drawing and graphic devices;

6) Information retrieval and storage equipment: file sorters, machines for document retrieval, special data and multipurpose electronic machines which possess a large volume of accumulators;

7) Communications equipment which transmits information: telegraph, telephone, radio, radio relay and telecode equipment, switchboards, selectors, document transmission equipment, and equipment for locating (summoning) officials.

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Electronic computers are the most important technical device of automation. They provide the complex processing of data by arithmetical and certain logical operations using number codes, and they also fulfill the functions of automatic correcting devices. Their use makes it possible to split the operating time of the individual parts of complicated ASUV. This provides an opportunity to use the same elements for performing several functions (see Figure 2).

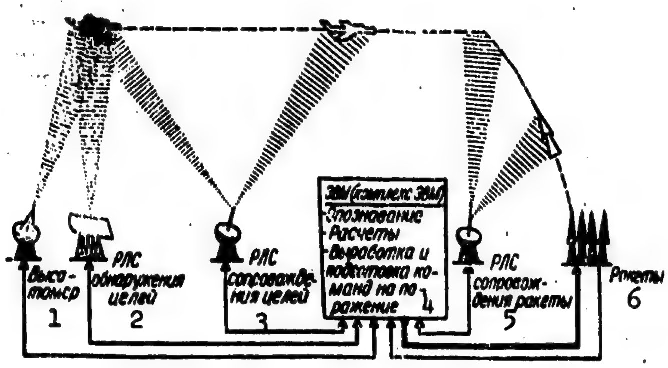

Fig. 2

Key: 1--Altimeter; 2--Target illuminating radar; 3--Target tracking radar; 4--Computer (computer complex): identification, calculation, generating and preparation of firing commands; 5--Missile guidance radar; 6--Missile

The proposed diagram provides a visual notion of the basic technical control devices in terms of a system for the automated control of air defense weapons.

Full mechanization of troop control accompanies the mechanization of control work and this presupposes the introduction and autonomous (separate) use of equipment which facilitates the manual labor of a person in control processes. The mathematical logical methods are employed here in the form of particular procedures which do not comprise a single complex of interrelated data processing problems. The high level of mechanization presupposes the complete or almost complete replacement of mechanical (manual) labor.

The most important functions of the ASUV are: A further rise in the combat readiness and capability of the troops; an increase in the efficiency of control and the effectiveness of using the forces and means in combat and an operation; reducing the volume of manual labor of the officials in the control bodies and freeing the commanders and staffs from unproductive technical work for creative activity in the area of troop control. For

raising the combat readiness and capability of the troops, in using automation, it is possible to employ modern mathematical logical methods and computer equipment in working out optimum plans and schedules using keyed calculators, punch calculators and digital computers for carrying out the necessary operational and tactical calculations and for improving the system for collecting, processing and issuing information on the basis of digital computers.

The rapid development of weaponry and the increased motorization of the troops have given combat high mobility, speed, surprise and decisiveness.

An acute need has arisen for reducing the time of handling information, for raising effectiveness of control and increasing the efficient use of the forces and means.

Reducing the time for handling information in the ASUV provides the prompt attacking of the most important enemy objectives, and contributes to the rapid shifting of efforts from one sector to another, the making of changes, when necessary, in already taken decisions, the adjusting of combat missions for the subordinate troops, the maintaining of close interaction between the subunits of the various branches of forces, and the rapid coordinating of their efforts. The obtaining of information on the situation, the state and nature of the operations of cooperating troops at the needed time provides for the rapid and more rational determining of the volume and content of measures carried out by each of these troop organisms, and increases the effective use of their possibilities under the specific conditions of the situation.

An important function of the ASUV is to increase the efficient use of weapons, to reduce the probability of their use against positions already abandoned by the enemy, and to increase the accuracy of the attacks made against the planned targets. For increasing the accuracy of hitting the targets, there must be complete consideration of many factors, precise information about the location of the target, the location of one's own troops and on other conditions for carrying out the mission.

Automation makes it possible to extend weapons more economically. This is achieved both by increasing the accuracy of fire as well as by selecting the most effective weapons and the methods of their use on the battlefield.

The possibility of rapidly analyzing different variations for hitting the planned target ensures the selection of the most economic of them with the set strike efficiency.

The problem of ensuring the most reliable defense of one's own troops against enemy weapons and a maximum reduction of losses in personnel and materiel is closely related to the problem of increasing efficient control and the effectiveness of using the weapons.

Automation makes it possible to increase the effectiveness of combat against weapons of mass destruction, to ensure the rapid collection of information on the radiation and chemical situation, and in a shorter time to take the necessary measures to maintain the battleworthiness of the troops. At the same time automation provides an opportunity to carry out calculations for forecasting the radioactive and chemical contamination and to ensure the prompt and even the selective warning of the troops which are threatened with the danger of attack. The use of automation makes it possible to quickly and rapidly evaluate the battleworthiness of the troops in strike areas, and to take sound decisions to eliminate the consequences.

Another function of the ASUV is to improve the efficiency of creative activities by all levels of commanders and staff officers by automating technical work. The efficiency of their activities is increased by using modern automation equipment and methods in a number of troop control processes. The ratio of the participation of a man in troop control and the use of equipment is a fundamental problem in automating this complex process. First of all automation is needed to ensure control over the types of weapons and for countering those weapons which possess high speed.

A most important function of ASUV is to provide the commanders and staffs with information on the situation using the results of carrying out operational and tactical calculations in the various hierarchical levels of control.

The system of technical automation makes it possible to realize on the computers of each level a large number of previously elaborated informational and calculation procedures which differ in the nature of collecting and processing the information in the process of solving them. The informational methods are related to the securing, collection, processing, accumulation, allocation and issuing of basic information on the situation and the conditions for carrying out combat. The solving of the informational procedures increases the effectiveness of control. The exchange of information on one's own troops and the enemy forces is accelerated between the subordinate, adjacent, cooperating and senior levels of control.

As a result of solving the informational procedures, it is possible to set up a unified data field (bank) which frees the officials from the labor intensive duty of inputting all the necessary initial data before solving each computational procedure on the computers of the ASUV systems and subsystems.

Automating the process of the exchange of information between control bodies as well as within them can make it possible with minimum expenditures of manual labor and time to solve one of the most important problems of control, the problem of interaction.

The information process in the ASUV should be organized considering the needs of each level of control. A larger amount of information is concentrated and processed in the superior level than in the inferior one.

In the general instance automatic and automated sensors and specialized computers can be the prime sources of information in the ASUV. The automatic sensors and computers determine the necessary information without human involvement while the automated ones do this with the participation of man.

The above-indicated primary sources of information, in keeping with the occurring changes in the situation, either by the established times or upon request, can transmit to the computers of the superior control levels the information on the situation, nature and direction of actions, the state and missions of one's own troops and enemy forces, as well as on the weapons and meteorological situation and the engineering work on the terrain. The information obtained from the primary sources is processed (generalized, compared, analyzed and systematized) by the computers of the superior staffs.

The necessary information on the results of enemy reconnaissance, on the position of cooperating troops and the nature of actions can be transmitted from the superior control levels to the subordinate ones. Moreover, the basic data from a commander's decision can be transmitted to them, mainly in the form of missions given to the subordinate level. Schematically this process is shown in the diagram (see Figure 3).

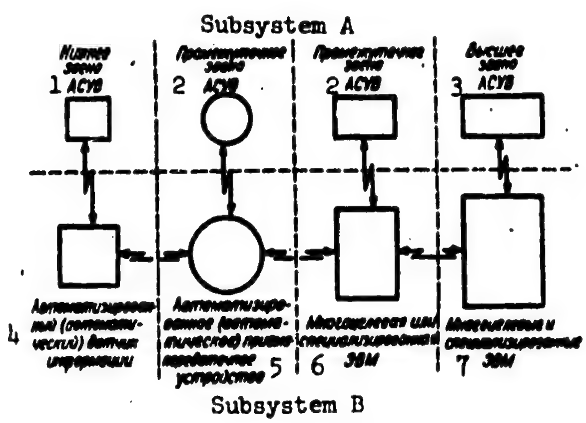

Fig. 3

Key: 1--Inferior ASUV level; 2--Intermediate ASUV level; 3--Superior ASUV level; 4--Automated (automatic) data sensor; 5--Automated (automatic) receiver-transmitter; 6--Multipurpose or specialized computer; 7--Multipurpose and specialized computers

Along with this, using the corresponding machine programs, information can also be exchanged between the computers of adjacent units and the subsystems of the ASUV.

The frequency of receiving information obviously depends upon its semantic content and varies for each control level.

The degree of detailing of the information should also be set depending upon the level of control and corresponds to the rules employed in the troops.

Automation can be carried out: In the direction of the autonomous use of the automation on the staffs; by creating individual systems of the different troop formations; in the direction of the integrated (systems) approach in creating the ASUV.

The autonomous use of automation on the staffs can accelerate the carrying out of operational and tactical calculations and other control work. However it does not properly increase the speed of handling the operational and tactical information.

The individual ASUV, when isolated from one another, also do not solve the problems. The automation of control of individual forces and means, even those playing an exceptionally important role in the achieving of success in combat (an operation), does not produce the desired results for raising the efficiency of control as a whole, since control over the individual forces and means to a significant degree is based upon the data of the general situation.

Only a comprehensive approach in creating the ASUV provides an encompassing of all levels from the interior to the superior, with the simultaneous meeting of the needs of all the troops and the use of the equipment which differs in purpose and capability.

Full automation presupposes a reciprocal link and interaction of the different equipment with the efficient use of the advantages of each of them in the control process. This also envisages a reliable connection not only between the individual elements of one level but also all levels of command. The necessity of comprehensive automation is dictated by the fact that the collection, processing and generating of information and above all the taking of a decision, the issuing of combat missions to the troops and the maintaining of their uninterrupted interaction represent a single and unbroken process.

The results of the collection and processing of data are the initial data for making the calculations, the result of which, in turn, operate as the initial data for adjusting the decisions.

The integrated use of diverse automation equipment can permit the simultaneous solving of both numerous individual operational-tactical machine procedures as well as a general mathematical model of combat (an operation), and provides a rapid transition from centralized control to decentralized, and vice versa.

Proceeding from the practice of the designing of automated systems for the needs of the national economy and considering the specific features of military affairs, it can be considered that the constructing of the ASUV should be based upon general (operational-tactical) principles, the principles for elaborating the software system, and the technical principles of creating the ASUV.

The first group of principles.

1) The development of ASUV considering the decisive role of man in troop control. The successful functioning of the ASUV depends upon the reliability of a multiplicity of diverse and extremely complex devices designed for the acquisition and accumulation of information, the transmitting of it over communications channels, the processing and generating of the results. However, regardless of the abundance of equipment, man plays the main role in the processes of troop control even with a very high level of automation; he evaluates the situation and takes the decision.

2) A combination of centralized and decentralized troop control requires the designing of the ASUV considering the providing of control functions on each level for the directly subordinate elements, and when necessary, one or two levels below. For this purose, for each level it is essential to use a definite degree of detailing the information in providing for the processing, generalization and aggregating of operational-tactical information as it is transmitted to the superior control levels. When it is necessary to obtain more detailed information on subordinates, an opportunity is provided for summoning such information from a subordinate level. In the subsystems and in each control level comprising the ASUV, their own information fields are created and these provide control within the subsystem. These make it possible, on the basis of initial data fed once into the computer, to solve various machine procedures using many programs. There are a link and intercausality between the information fields of the various levels, subsystems and systems. Such an organization of the information process, along with the possibility of switching the automation equipment across one or several levels and the autonomous solving of problems in each control level, should provide an opportunity of both centralized as well as decentralized troop leadership.

3) The principle of mobility means that the ASUV should ensure a possibility of controlling all types of troop combat characterized by a high pace of advance. The actual realization of this condition is achieved by mounting the automation equipment on a highly mobile transport base which at the same time provides work areas for the personnel. On the tactical level it is desirable that the automation and communications complexes exercise control while the means of transport are in motion.

4) The principle of ensuring flexibility, stability, secrecy and continuity of control in the ASUV proceeds from a consideration of the nature of modern combat under the conditions of the massed use of nuclear missile weapons and other powerful weapons.

5) The principle of an optimum combination of the possibilities of man and automation requires, in designing the ASUV, a rational assigning of functions to each element of the system considering the particular features of the equipment and the psychophysiological characteristics of man. The ultimate aim of such an allocation consists in creating an efficient ASUV which provides efficiency and convenient work for the commanders and staff officers.

For realizing this principle in creating ASUV, in our opinion, it will be necessary:

a) To determine those parts of the control process which can be entrusted to the automation and work out the corresponding machine procedures for solving them on a computer;

b) To envisage automated work areas for personnel on the corresponding highly reliable transport base which possesses good cross-country capabilities;

c) To ensure the giving of the results of computer data processing to the officials in the conventional visual form using the most rational equipment and methods for putting out the information;

d) To maintain contact for the officials with the unautomated control areas and levels by equipping the work areas also with conventional means of control and communications ensuring a transition from automated control to conventional in the event of a breakdown of individual sections and levels of the ASUV;

e) To maintain a succession in the work methods of the commanders and staffs ensuring a gradual transition to the new work methods of the ASUV without any decline in the combat readiness of the troops and the quality of work done by the control bodies.

6) The principle of successive stages of work in developing the ASUV proceeds from the importance of the problems solved by the systems, the presence of theoretical and technical studies and the possibilities of organizational decisions, including the elaboration of a software system for the ASUV and the training of special personnel for operating the equipment of the system and using it as a whole.

The second group of principles.

1) The creation ahead of time of the algorithmic languages and translators for the purpose of accelerating the elaboration of the machine procedures (programs) and ensuring data compatibility for the various computer models.

2) Determining the list and sequence of working out the individual machine procedures (programs) and groups of programs up to mathematical models, inclusively, ensuring the most efficient use of the ASUV as a whole and the computer in particular.

3) The creation of data fields (files), the rules for their transformation and use. Consideration of the particular features of the software.

4) The development of an operations system ensuring the control of the computer processes in the ASUV, and providing a link between the programs and data files.

5) The elaboration of service programs which control the work of individual elements of the system, including the peripheral ones, as well as the ASUV as a whole.

6) Giving definite priority to the software. In line with the great labor intensiveness and significant cost of this work, up to 70-80 percent of the cost of developing and introducing the ASUV occurs in the area of software.

The third group of principles.

1) Elaboration of the system's elements on a modern technical base. The high effectiveness of ASUV can be achieved only on the basis of applying the most recent scientific and technical achievements.

2) The maximum possible standardization of the system's elements. This principle is of exceptionally important significance from the viewpoint of both organizing the production of automation equipment, its operation and repair under field conditions, as well as ensuring the stability, flexibility and reliability of the system's functioning under the conditions of enemy action. The realization of this principle can also facilitate the linking of the individual subsystems. With a desire for maximum standardization of the system's elements, one must also consider the specific requirements of the various troop formations, as a consequence of which standardization cannot be absolute and is applied in optimum limits.

3) The prospects of the system. In working out the structural system of the ASUV and automation equipment, it is essential to provide an increase in the equipment and the capabilities of the system without a fundamental change in the structural system and the principles for organizing the information process in the system. New automation and communications equipment should fit into the structural scheme of the ASUV and this, in turn, must provide for the connecting of new automated control elements and the extending of the degree of automation by increasing the list of solvable machine procedures.

4) The combining of the preparation of primary documents with putting into the computer. The essence of this principle comes down to revising the document processing and to establishing uniform standard (formalized) samples for putting in the information. This makes it possible to achieve uniformity in the systems of accounting carried out by man and the computer, and when necessary to move from automated data processing to conventional, and vice versa.

5) Observing the principle of precise work by the automation equipment should not complicate their design and operation. The number of equipment types in automation and mechanization must be restricted within advisable limits; the equipment which directly connect the commanders and staff officers should be particularly simple to use. This can permit a reduction in the number of service personnel and thereby a simplifying of the control system.

Simplicity and standardization of design for automation equipment have a direct influence on the speed for training the personnel of the units and subunits. They are of great importance also for connecting the various elements of the control system. The simplier the devices for connecting the various types of equipment, the more rapidly it is possible to bring the control system to a state of combat readiness and disassemble it for moving its individual elements. This is of important significance for increasing stability and continuity of control, particularly with the high pace of the advance of the troops and the rapid changing of command posts.

The automation equipment should also ensure maximum convenience for the locating, transferring and working of officials in all the control bodies.

6) One of the most important principles is economy. The introduction of automation should ultimately lead to a reduction in the cost of the control system as a whole with an overall rise in the efficiency of its operation.

In our opinion, the principle of economy can necessitate considering the existing organizational staff structure of the troops and the staff in working out, introducing and operating the ASUV equipment.

The structure, functions and principles for organizing the ASUV are realized in the specific systems in accord with the development level of science and technology and the requirements of military affairs. Naturally, the methods and forms of this realization are not the same in the various stages. Equally different are the levels of the possible and necessary automation. For this reason it is particularly important to analyze the present state and prospects for the development of ASUV.

2. The Present State and Prospects for the Development of Automated Troop Control Systems[1]

In the U.S. Armed Forces, starting approximately in 1965, there has been the development of automated tactical and strategic control systems. The

tactical ASUV are designed for controlling the combat of units, formations and field forces within a theater of operations.

The measures to work out automated control systems for the U.S. ground forces were carried out in three stages.

In the first stage (1954-1961), scientific research was carried out and work was done under the Fielddata Program. Under this program there were plans to develop models of computers, programming devices, data transmission equipment, input and output devices, as well as studying the procedure for utilizing all of this equipment in the troops. The carrying out of the Fielddata Program continued up to 1966 and ended with the development of the prototypes of individual automation devices wuch as the Moby Dick, Basicpac, Compac and Fadac computers.

The second stage (1960-1965) involved the carrying out of the Armydata Program according to which there was to be thorough field and troop testing of equipment developed under the Fieldata Program, a generalization of the results obtained in the testing process, the introduction of necessary changes in the design of the individual automation models, as well as the development of new types of equipment. However the given program was not fully carried out. In the testing process serious design shortcomings were detected in it.

The third stage (since 1965) started with work on the new Adsaf Program. The system provided for three subsystems: The control of combat, the control of field artillery fire and the control of material and technical supply. Around 1 billion dollars were spent on carrying out this program.

An ASUV for a field army often consists of three subsystems: Tactical, artillery and rear. The first subsystem of the TOS is designed for collecting, processing and displaying the information needed by the command of a field army, corps and division for decision taking.

The tactical subsystem will consist of automated control centers for the divisions, corps and the field army and a complex of technical devices located in the units.

These technical devices which are the sources of primary information are designed for obtaining data on the situation from subordinate units.

The TOS system envisages the automating of a significant number of troop control processes. Among the tasks which should be carried out in the automated system, the following are mentioned: Collection and evaluation of data on the situation, composition and nature of the operations of one's own troops and enemy troops; collection, analysis and generalization of data received from strategic, air and field reconnaissance; the planning of troop operations (the use of nuclear weapons, the eliminating of the consequences of an enemy nuclear attack, tactical air support, air defense

for the troops and rear installations, the organization of communications and the carrying out of radio electronic countermeasures, engineering support for combat and calculating the fire interaction lines); calculations related to conducting special types of warfare (chemical and biological contamination, operations in the enemy rear, psychological warfare); various calculations to support troop combat.

As a total the automated system is to solve 30 operational-tactical problems which will make it possible more effectively to evaluate the situational data and prepare sound proposals needed by the commander for decision taking.

The structural scheme of the automated TOS system includes a network of computer centers and terminals for the inputting and outputting of information. The basis of the system is the main computer center of the field army connected by communications channels to the local computer centers of the subordinate corps and divisions; the latter centers are located at command posts. Each local computer center, in turn, is connected by communications channels with the terminals; it is also equipped with technical data pickups which are located in the brigades and battalions.

The scheme for the receipt of data at the main computer center of a field army is as follows. Information from the forward observation points, the reconnaissance patrols and combat subunits is sent to the terminals of the battalion and brigade control points located on armored personnel carriers. After this the generalized information is transmitted to the local computer center of a division the equipment of which is located on two 2.5-ton vehicles. From the local computer centers the information is transmitted to the main computer center both in the rough form and also partially processed. The structure of the system makes it possible to exchange information between any computer complexes of the field army. Through the main computer center there is the possibility of exchanging information with other armies and commands of the ground forces in theaters of operations and in the continental United States. At the end of 1967, an experimental model of the automated system was developed. Its structure included the main computer center, 4 local computer centers and 18 terminals located on 21 carriers. The prototype was delivered to the staff of the Seventh Field Army in Europe where the system underwent testing. In 1969, the equipment of the computer centers and terminals was distributed between the staffs of the American ground forces in Europe for carrying out field testing and this is still going on.

The main computer center is located in four trailers (one 12 meters long and the other three 10.5 meters each). The computer center has a Control Data CDC-3300 computer. It has a speed of 400,000 operations per second and an operational memory of 65,536 24-digit words. It is housed in four units. The external magnetic disc storage has a capacity of 100 million binary digits. A special device provides for the connecting of the computer with 13 duplex communications channels. The local computer center

is carried on two vehicles. It is equipped with a CDC-1700 computer with a speed of 152,000 operations a second and an external storage of 590,000 binary units. A special device links the computer by communications channels with eight terminals.

In the terminals two types of equipment are used: an individual display unit and an electric typewriter. The individual display unit has a cathode ray tube with a screen 15 x 20 cm in size making it possible to display up to 1,000 alphanumerical signs (20 lines of 50 signs each). The data is fed in by a keyboard in the following manner. The operator types in a command by which the format of a coded message is displayed on the screen with the required working tag. Then, in using the keyboard, he fills in the text of the message in the free areas. After checking the correctness of the text and correcting the detected errors, the operator presses the "Send" key. The message is automatically transmitted over the communications channel to the local computer center. The same device is used for receiving short coded messages.

Electric typewriters are used for receiving the basic bulk of coded messages. They operate at a speed of 150 lines a minute and print text in a standard format of 120 signs per line. When necessary the required number of copies of the received messages can be produced.

The basic equipment of the automated system has been developed on the basis of integrated circuits. This makes it possible to make the equipment compact, to achieve high reliability in work, and due to this the average accrued working time per failure of the entire system is not less than 150 hours, and the average time for correcting the malfunction is 30 minutes. The exchange of data between the computer centers and the terminals can be carried out also by special control programs. Any of the users connected to the system has an opportunity to turn to the computer center and receive the data of interest to him, indicating in his requests the nature of the required information, the period of time and the region of combat. In finding the reauired information in the storage units, the computer forms the reply coded message and sends it off to the user. For the continuous receipt of current information, an official can send an instruction request which gives the time for the delivery of the needed information. After receiving the instruction, this information is sent out to him automatically. In addition to requests from the terminals, data coded messages will be received continuously and these contain new information on the situation. The data files of the computer centers are renewed by them.

American specialists feel that the achievements in the area of communications systems and ratio electronics will make it possible by the time the TOS system is put into service (by the middle of the 1970's) to carry out an exchange of data between computer centers at a speed of 38,400 bauds and permit not more than one mistake per million transmitted signs.

The Tacfire artillery fire control subsystem is designed to automate the processes of controlling artillery units starting from the command of the divisional artillery and ending with the forward artillery spotters. Such a system will make it possible to solve 24 different problems in the artillery battalions. The main ones are: the processing of reconnaissance data on the targets as received from the forward spotters and from other elements of command; the carrying out of ballistics calculations for the three coordinates and the preparing of fire control commands; the collecting of data on the state of the fire subunits (the number of personnel, position, combat capabilities, availability of weapons, ammunition supply, and so forth). It is felt that with the availability of data on the position of one's troops, isolated targets, the contents of the missions and the available ammunition, the subsystem makes it possible to draw up a firing plan in 15 minutes. The Tacfire Subsystem has been developed by the Layton firm, using the experience of developing and using in the troops analogous-purpose equipment with a Fadac computer which in artillery battalions automates the processes of fire preparations and its correcting (the Fadac computer was developed under the Fieldata Program).

In December 1967, the command of the U.S. Ground Forces allocated 122 million dollars for manufacturing the equipment of the Tacfire Subsystem for for the fire control centers of the artillery battalions and the command posts of the divisional artillery. In addition to developing this, the Layton firm has developed a family of computers with programming devices which in the future could be used in other subsystems, in particular in the combat control subsystem of the TOS.

Before the troops had received the Tacfire Subsystem, the command of the U.S. Ground Forces planned to use equipment with the Fadac computer which began to be received by the troops in 1961. In 1965, the American troops had already 148 such machines which after repeated improvements received high praise in the troops. The Tacfire Subsystem includes computers and peripheral equipment used in artillery battalions and at the command posts of divisional artillery, as well as the battery console and a data input device from the forward spotters. The peripheral equipment includes: The fire control console, a data display device, a printer, a mechanism for storing and feeding in programs and data output terminals.

The L-3050M electronic computer was developed on the basis of the 3050F aircraft integrated circuit computer. Its basic data are the following: Binary number system, digit configuration--32 signs plus parity check sign, speed--220,000 operations per second, and mean time between failures --1,000 hours. The operational storage is on magnetic cores and the capacity of each of its four blocks is 8,192 words. The design of the machine uses up to 6,000 integrated circuits. The logical elements are made using circuits of the transistor--transistor type having a speed of 5-6 nanoseconds (1 nanosecond--1 billionth of a second).

The high operating stability of the computers in the Tacfire Subsystem is achieved by using high reliable integrated circuits and other components as well as by the possibility of duplicating their work. It is proposed that the fire control centers of the artillery battalions would have one computer each. In the event of the failure of a computer at any fire control center, the solving of the basic problems would automatically be transferred to one of the machines at the divisional artillery command post.

The divisional artillery command post should have two computers which could function both simultaneously or one operating and the second in reserve. Along with the computer there are also plans to use a magnetic drum external storage with a capacity of around 10 million binary signs.

The fire control panel is used for the work of the operator in controlling all the equipment of the system and for feeding the necessary data into the computer. Moreover from the board there is the assigning of targets among the batteries and data are issued needed by each battery for firing. The control board has two cathode ray tubes (one for recording the input data and the other for displaying the output parameters in an alphanumerical form) and a standard keyboard.

As the data display devices in the Tacfire Subsystem, electromechanical plotting boards are used (for displaying the tactical situation in the entire area of troop operations) and a CRT display (for displaying the situation in individual combat areas). On a plotting board with an area of 0.37 m^2 against a background of a topographical map using symbols the sector boundaries, the engagement zones, the location of targets and so forth are displayed. All the data or parts of them are renewed using the computer and the fire control panel. The individual elements of the tactical situation are shown on the display using lines and 250 various symbols. The control of the CRT display with a diameter of 40.6 cm is carried out only by the computer.

It is assumed that the electronic plotting board will be used at the command post of the divisional artillery and in the fire control centers of the artillery battalions; the CRT display will be used only at the command post of the divisional artillery. The development of a large-screen display using integrated circuits is considered promising.

The printer of the Tacfire Subsystem is of the noncontact (photoelectronic) type, with a speed of 600 times per second. It employs a cathode ray tube and fiber optics. The data are generated in an alphanumerical form by photoprinting on paper.

Among the peripheral equipment which is not part of the basic equipment one would mention the program storage and input device, the data output terminals and the monitoring and testing equipment. In the fire control centers of the artillery battalions and at the divisional artillery command post, several magnetic tape units are used for storing and feeding

various programs into the computer and four terminal semiduplex data transmission devices which transmit the data over the artillery communications lines at a rate of 600 and 1,200 bauds.

The device for feeding in data from the forward observers is designed for drawing up standard requests for opening fire and their subsequent transmission to the fire control centers over the wire communications lines or using the army radios. The device has 25 switches by which the observer compiles a standard message and a shift register which has two circuits with a high level of integration. Each of them uses up to 100 components. The instrument weighs 2.3 kg.

The approximate operating scheme for the Tacfire equipment is as follows. The forward observers over the wire communications channels or by radio transmit their messages to the fire control center and approximately 2 seconds later receive an audio response signal which affirms the reception of the message. The standard request for opening fire received from the forward observer includes a call code which will be periodically changed for maintaining secrecy. The information signs contain data on the target such as its location, altitude, type and dimensions.

The forward observers can also transmit certain recommendations. For example, what type of projectile or type of explosion (air or ground-level) would be better for destroying the detected target.

In the fire control centers the requests coming in from the forward observers are received by the terminal and fed into the computer where the necessary calculations are made and the fire control commands are generated. Then these commands are sent to the control board and are shown on its display while the target coordinates are entered on the plotting board. When necessary, the operator from the fire control board at any time can make changes or additions in the initial data, after which the computer recalculates and puts out new control commands. After the taking of the decision, the control commands are transmitted to each battery over the communications lines where they are received by the board and shown on its display.

All of the equipment of the Tacfire Subsystem designed for use in the artillery battalions and at a divisional artillery command post can be carried in truck trailers or a staff armored vehicle.

The subsystem for the control of material and technical supply is designed for controlling the rear troop services. It provides the following: Calculations for material and technical supply, technical supply of the troops, accounting for personnel, weapons and equipment, and calculations for financial and medical support.

In 1967, three experimental models of the subsystems were manufactured. In 1968, one of these was delivered to the U.S. Seventh Field Army for

field testing. The subsystem included: an IBM-360/40 electronic computer, a magnetic disc storage and equipment for the data transmission lines. All the equipment was to be located in four trailers. The first trailer, along with the computer, was also to carry the auxiliary equipment (the printers, the equipment for reading data and punch cards, and so forth). The magnetic disc storage was to be in the second trailer. It would have a capacity of 233.4 million bytes (1 byte--a unit of information in a machine corresponding to one letter, one symbol of the alphabet or two decimal figures; it corresponds to eight binary signs). The retrieval and selection of the data from the memory is made at a speed of 312,000 bytes a second. And additional storage consists of several magnetic tape units.

The equipment of the data transmission lines is housed in the third trailer. It provides two-way communications with the terminals used for the remote digital data input and output as well as for connecting with other subsystems by wire and radio. The terminals are located on 2.5-ton army trucks. The auxiliary equipment is carried in the fourth trailer. Also there are the spare units and devices. In the opinion of American specialists, the CS-3 subsystem will make it possible to automate a larger portion of the processes involved in troop material and technical supply. However, the most important functions, for example, the taking of decisions or the canceling of requests will remain for the commanders.

In the assertion of competent U.S. bodies, the development of a unified automated system for controlling the ground forces not only entails great outlays of money and time, but also requires definite experience both in the development of technical devices and in seeking out effective methods for using them. A particularly important and complicated problem is the software of the automated system.

The 485L automated tactical aviation control system is designed for automating the processes of controlling the operations of tactical air formations in a theater of operations. The system consists of the following subsystems. The subsystem for controlling and guiding the tactical aircraft should ensure the solving of problems related to the automated detection, identification and tracking of aircraft in the zone of operations. It includes the following control elements: The tactical air control center (the basic control body), the warning and control center (the main body), the air observation point and the air traffic control center; two warning posts and four forward guidance posts which provide direct guidance of the aircraft to ground targets in carrying out air troop support.

The direct air support subsystem is designed for solving the problems of the cooperation of tactical aviation with the ground forces. In structural terms, it combines: The direct air support center which is located together with the operations center of an army corps; the tactical air control groups and the control points for the formations and units of the ground forces; an air traffic control subsystem which is designed for controlling and monitoring air traffic in the area of airfields.

According to the development program of the system, there is to be the development of mobile radio communications and radar equipment for outfitting the tactical air command bodies. This equipment includes: Equipment for the warning and control centers, the direct air support centers, radars, single sideband shortwave radios, switching equipment and other equipment. Basic attention has been paid to the compatibility of the new equipment with the equipment for the tactical automated control systems for ground forces and the navy.

Subsequently, as the system is gradually developed, there are plans to carry out work in raising the level of its automation. According to information from the American military bodies, the full automation of the system will be reached in the 1980's. The system will be based on a central processor connected by data transmission lines with small computers located at the command posts of the forward air units. In carrying out the basic work of data processing, the electronic computers free the central processor for carrying out more complicated tasks such as drawing up the drafts of combat orders, analyzing possible variations of aviation operations, generalizing reports and correcting the plans of air operations with a change in the combat situation.

American military specialists estimate (from the experience of the war in Vietnam) that the time for planning operations in a number of instances was reduced from 10 hours to 10 minutes, while the cycle for planning transport flights (1,200 sorties per day) was reduced from 14 to 4 hours.

The IBM-360/50 computer which is part of the system has a speed of 250,000 operations per second, a capacity of the operational storage up to 16 million binary units, and a capacity of the external storages of several billion binary units.

The automated control system for a formation of NTDS ships is designed to control combat of an operational-tactical formation of U.S. Navy ships. This system makes it possible to automate the most labor intensive processes of ship control. These include: The collecting and processing of data on the situation, the carrying out of operational-tactical calculations needed by the commander for decision taking. The automated system solves the following problems: Controlling the landing of carrier-based aviation; controlling the operations of launches; making missile and artillery strikes against shore targets; air and ASW defense of the ships; the intercepting of air targets. It has been proposed that the system include three computers and displays. In the system they plan to use a computer with a speed of around 700,000 operations per second and a capacity of the operational storage of 32,000 words.

The automated MTACS system is designed for controlling Marine operations on the level "expeditionary corps--division--air wing."

The system which should be in operation by the end of the 1970's will include a network of mobile data processing centers and automated work areas of the control bodies. The structure of the automated Marine control system represents a combination of elements from the structure of the automated ground forces and tactical aviation systems.

The small computers and automated operator work areas are also among the automation equipment of the systems.

The basic tasks carried out by the MTACS system are: Collection, processing and analysis of data on the enemy, on the state and nature of the operations of the Marine formations and units; displaying the sea and ground situation for the purposes of quickly taking decisions on the rational use of the Marine forces and means; the carrying out of calculations related to the planning and execution of combat as well as to the organizing of cooperation and all types of support.

At present the United States has set up a global automated armed forces control system. According to a statement of American military specialists, it provides the higher U.S. military political leadership with an opportunity to dependably and flexibly control the armed forces on a broad scale in peacetime and wartime. Its main component is a national armed forces control system which includes a complex of stationary and mobile command centers and posts linked into a system by communications. The basic centers of this system are: The national command center, the emergency national command center, the emergency floating command post and the emergency air command post, as well as the command posts of the armed forces in the zones and special commands of the United States. The National Command Center located at the Pentagon is staffed by representatives from all the services of the armed forces. It receives information from all the centers and posts, from civilian institutions, and this is depicted on large wall maps and light screens. The data received from the command posts of the Strategic Air Command and from the automated NORAD air defense system are automatically reproduced by the Iconorama system. These include signals from the BMEWS Ballistic Missile Early Warning System and the SPADATS Space Detection and Tracking System. The electronic computers of the center make it possible to carry out rapid data processing and put out the data on a printing, and display unit. As was stated by the American press, the National Command Center receives over 1,000 messages daily. The emergency command centers and posts are designed for providing uninterrupted control of the armed forces in a nuclear missile war.

The strategic control ships "Northampton" and "Wright" are used as an emergency floating command post. For example, the ship "Northampton" has a large communications center which includes 60 transmitters and 150 receivers. The capacity of the communications center is up to 3,000 telegrams a day. It provides radio telephone, teletype and phototelegraph communications, as well as the exchange of computer data with all regions of the world. The ship carries a tropospheric communications radio station which provides multichannel telephone communciations and data transmission

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for computers (over a distance of up to 800 km), as well as a space communications station. The ship has several computers for solving information and computational problems. The emergency air command post of the U.S. Armed Forces has been set up on five EC-135 aircraft. One of them is constantly on a 15-minute alert at a base near Washington or in the air. The cruising speed of the EC-135 turboprop aircraft is 850 km per hour, the range without refueling is 10,000 km. The aircraft is equipped with an AW/APC-89 radio operating in a band of 225-240 megahertz, as well as shortwave transmitters. On board there are a total of seven-nine transmitters with a power up to 1 kilowatt, a number of receivers and up to 30 special antennas. The AW/APS-89 radio provides an opportunity for simultaneous conversations over 51 telephone channels both with ground centers as well as with the other air command posts over a distance of direct line of sight. On shortwaves communications is possible at a distance up to 6,000 km.

The command posts of the services of the armed forces have automated equipment for the collection, processing and transmission of data. The command post of the ground forces is equipped with the DACC automatic control system which provides the army leadership with the information necessary for taking decisions and transmits orders and instructions to the executors.

At the command post of the naval forces is located an information center with three computers and automatic and semiautomatic situation display equipment. The center receives information on the location of U.S. naval ships and merchant vessels as well as those of other nations. The continuous updating of these data makes it possible at any moment to obtain information on the ships and vessels located in a given area. The control elements of the joint commands are in touch with all the leading points of the subordinate units and themselves are part of the global armed forces control system.

According to the data of the foreign press, the most equipped is the NORAD command post which since January 1966 has been located in underground quarters near Colorado Springs.

The basic sources of information for the NORAD operational command center for the questions of antiaircraft and antimissile defense are the following automated systems: The stations of the BMEWS Ballistic Missile Early Warning System located in England, Greenland and Alaska; the stations of the DEW Aircraft Early Warning System located somewhat to the north of the Arctic Circle, along the northern coast of Canada and Alaska (the length of the line is over 8,000 km), while its flanks are guarded by aircraft and ship radar pickets in the Atlantic and Pacific; the stations of the Mid-Canada Subsystem in the central part of Canada; the stations located along the northern U.S. boundary, the Pinetree System; the stations located along the eastern, southern and western frontiers of the United States.

In addition to the given automated systems, the NORAD Operational Command Center is supplied with information from the SAGE System which has been in operation since 1961 and monitors the air space over the North American continent.

The creation of such a complicated warning system, information equipment and active defense cannot be done in a short period of time. For this reason foreign military specialists have felt it necessary to deploy the warning systems in peacetime and to maintain them in a high state of readiness.

Thus, as is seen from foreign materials, modern ASUV make it possible to automate a significant number of troop control processes, to carry out complex operational and tactical calculations for the use of forces and means in operations, and to receive and process large amounts of information.

As was already mentioned, the third generation of computers has presently been created and is being actively introduced. According to statements in the foreign press, the electronic computers of the fourth generation will be in practical use in the 1976-1978 period. Already their first models are based on large integrated circuits, a large capacity semiconductor memory, and large systems modules. In the machines of this generation, the large integrated circuits will perform the functions of entire subsystems. The speed of these machines will approach a billion operations per second. The hardware is to be realized according to the principle "what is to be done?" and not "how is it to be done?" The use of natural languages will be characteristic.

In recent years abroad there has been a stronger tendency toward the development and introduction of small machines. Foreign specialists estimate that the small and minicomputers together with large computers are completely essential elements in an automated troop control system. The many computers differ from the small, medium-sized and large ones in the shortened length of the machine word, in smaller size, more limited computational capabilities and lower cost.

Undoubtedly the automated control systems will incorporate a significant number of small computers, particularly as peripheral components at automated work areas of control bodies.

The further development of the computers and the other automation equipment and the improvement of their software will make it possible to more widely apply ASUV in peacetime and wartime.

Considering what has been given above, the future development of computers can be predicted.

The most important problems which must be solved in developing the future electronic computers are a rise in speed and greater storage capacity.

Here the direct path does not always lead to the desired results. Many difficulties have been encountered in moving on to a nanosecond mode in the instance of carrying out numerous operations and also in interconnecting the individual components of electronic circuitry. No matter how quickly the microprocesses occur, they still have a finite limit. In using conventional data processing methods, the limit is approximately 10^{10} logical operations per second. The given operating speed is not absolute. It can be increased by using parallel operations with images (machines with a "picture logic"). As is known, in modern computers each switching device at a given moment of time remembers one element (bit) of information. However the speed can be increased if the data are processed in whole files or "pictures" of information. In cthers words, the computer system must be created in such a manner that each switching component simultaneously translated a "picture" consisting of 10^8-10^{10} bits of information. Thus, the principle of "picture logic" makes it possible to increase the computer speed approximately by 10 magnitudes (by 10^{10} times).

An increase in the computer memory capacity is achieved by employing various storage units with a high data recording density.

In using coherent light sources, for example lasers, in a small crystal volume it is possible to record as "pictures" an extremely large amount of information, and then reproduce it with minimum distortions. In this instance the density of the data recording tentatively reaches an amount of 10^{12}-10^{13} bits per cm^3. Thus in each cm^3 of crystal it would be possible to contain information found in a library of 5 million volumes of 200 pages each. The problems of using coherent light sources for the purpose of obtaining three-dimensional images are the concern of the young science of holography (from the Greek "holos"--full, and "grapho"--I write; literally--"full notation").

Holography is most widely used in computers. The density of data recording in holograms (in a thick-layered emulsion) will reach astronomical amounts of 10^{12}-10^{13} bits per cm^3 as in crystals. This is three-four magnitudes higher than the density of information recording in biological neurons.

Holography opens up broad opportunities for constructing a new class of storage units. The use of associative memory in a computer will make it possible to reduce by many-fold the volume of the program in comparison with the ordinary presently used memory, where each word has a fixed address recorded in the machine program. On a hologram it is possible to record not only an image of objects, but also any other information given, for example, in the form of tables, graphs, printed text and so forth. It would be hard to overestimate the advantage of feeding information into a machine in such a form. In this instance the cumbersome and extended process of recording the information on a punch tape with the subsequent feeding of it into the machine would be excluded. Here the information could be recorded in the form of interference "pictures."

The process of retrieving information contained in a holographic storage would be carried out virtually simultaneously for its entire field, regardless of how great or multidimensional it would be. Since interference "pictures" created by lasers of other frequencies can be stored in the same volume, the crystals as by their very nature would be used for creating associative memory in the computer with an enormous volume of information. According to data in the foreign press, a number of firms are already developing holography-based storage units.

The practical realization of industrial models of holographic storage units will depend upon the solution to a number of problems, and in particular, upon finding a material which would provide for the rapid recording and destruction of the holograms.

Thin magnetic films with bismuthmanganese composition would be one such material. Their use along with high output lasers (on the order of 100 kilowatts) would make it possible to actually realize a holographic memory.

The Honeywell firm has built an experimental holographic storage unit on bismuthmanganese film with a data recording density of 20 million bits per cm^2. The information is recorded by the beam of a helium-neon laser (a pulse of microsecond duration and a power of several milliwatts), and readout is with the same laser. In design terms such a memory is a rotating disc 15 cm in diameter with strips of the carrier material applied to it 2.5 cm long.

The French firm Thomsa-CSF has developed a storage device in which one hologram 1 mm in diameter will store 10,000 bits of information. One of the Japanese firms, Hitachi, has designed a holographic device on multilayered ceramics with a data storage density of 20,000 bits on an area 0.5 mm in diameter (this corresponds to a density of 20^7 bits square per cm).

The given examples show that the scientists of many nations are intensely developing fifth generation computers and the scientific prospects are being determined for creating super high-speed computers with enormous memory capability.

The communications channels with the connecting devices are an important element of any ASUV. Without high quality communications channels linking the computers to the peripheral sources, there can be no question of an automated system. Of course, autonomous use of computers is possible and justified, particularly in the area of scientific research. However, in the process of troop control, automation provides a great impact in close interaction with all the means of communications.

The output devices from the computers are the work areas of the control bodies (usually at command posts), the equipment of which makes it possible to communicate with the computers.

The above-indicated equipment includes: Data input and request devices, an arithmetic digital printer, a data visual display device, equipment for documenting information and reproducing the documents.

The data input devices are used for inputting data related to the competence of the specific control body. In accord with the changing situation, particularly in the course of combat, a large portion of the information is continuously changed, some data grow out of date, and because of this they must be replaced. The basic portion of information on the situation will come from below, from the subordinate automated systems. From the automated work areas it is possible to feed in information relating to major changes in the tactical and technical data, the methods of employing weapons and military equipment, as well as operational and tactical standards related to one or another branch of forces.

The request devices are designed for putting into the machine a coded request for solving informational and computational problems and providing the obtained decisions to the automated work area. The results of the solution are directly employed by the control bodies for analyzing and evaluating data on the particular situation and for preparing proposals for the taking of a decision by the commander.

The arithmetic digital center is a terminal element in any electronic computer. It may also be located a distance away, at an automated work area.

In this instance it is used to give the results of solving informational and computational problems directly to the work area, and in the form of printed documents which can be used directly by the officers of the control bodies.

According to foreign data, modern arithmetic digital printers operate at a speed of 400 lines a minute (the length of the standard line is 60 signs). The further development of computers will make it possible to increase the speed of generating information from the machine.

The visual displays of the foreign ASUV are a complex of screens, boards, and electrified plotting boards on which the necessary information can be produced in the form of graphic images of the situation on screens with a cartographic situation, various reference tables, schedules, and so forth. The visual displays are an important technical means for carrying out troop control under the conditions of a rapidly changing situation.

Certainly such significance of the data visual display devices becomes possible only with technically advanced sources of primary information which quickly secure and transmit the situational data to the computers. Foreign specialists feel that regardless of the fundamental possibility of the graphic display of the situation concerning the enemy and one's own troops on automated screens with a cartographic base, the map as the most

important working document of the commander and staff will maintain its significance. On it are plotted the variations of solutions, and it is one of the basic documents used by the staff in planning operations and combat, in giving missions to subordinate troops and in exercising control over the course of the carrying out of the given missions by the troops. For this reason, simultaneously with the development and improvement of the automated control systems, it is considered essential to increase staff efficiency, and in particular to improve in every possible way the methods by which the officials work with a map.

The display devices are an important element in the automated control system and can be used in control bodies in the form of collectively used screens or individual situation display devices. In the foreign ASUV, for obtaining images on a large screen, four methods can be used: Direct projecting from the screen of the cathode ray tube, projecting using an intermediate recording of the image, and an image based on discrete or laser equipment. Thermoplastic, photoplastic, photochromic, discrete and laser technologies are promising ones which may find use in display units abroad.

Thermoplastic technology consists in recording information by an electron beam on a thermoplastic film. This provides a sufficiently high resolution and a short time for holding the information on the screen (up to 0.5 second). Obviously this technology will be used on collective-use screens of medium size with an area up to 2-3 m^2.

Photoplastic technology uses a combination of the photoconducting and thermoplastic properties of substances. The obtaining of a potential relief is achieved by recording the image with a light beam, and the role of the converter of light energy into electric is played by a photoconducting layer. This technology can be used most in individual display devices for graphic and letter printing information on the staffs of formations and units.

Photochromy uses the property of substances to change color and transparency when exposed to radiant energy of different areas of the spectrum. The photochromic films excel in high clarity and good operating properties. This technology will obviously be used most in developing large collectively used screens on the higher staffs.

Discrete technology is based upon the use of individual miniature elements (modules) ordinarily reproducing one data symbol for its set on set-sized screens.

Abroad it is felt that the modules can be developed on the basis of light-emitting diodes, liquid crystals, plasma films and other elements. Light-emitting diodes are semiconductor devices which use the phenomenon of injection electroluminescence. The first examples developed in 1968 emitted only red light. At present, a broad range of the spectrum has

been developed, and for this reason it is possible to create elements of various colors. The light-emitting diodes are made in the form of separate modules which are capable of displaying one sign. The set of individual modules provides an opportunity to create a screen of the necessary size. The light-emitting diode screens will possess high reliability, good clarity and resolution (up to three elements per mm), and a low data display lag time (an inertia on the order of 10^{-8} seconds). The light-emitting diodes will be widely used in display devices for both collective and individual use on the staffs.

Liquid crystals can be used in display devices on the principle of a change in their transparency under the effect of electric voltage. These are placed in a thin layer 10 microns thick, between transparent plates and electrodes to which a current is delivered with a power of several watts. The change in the transparency of a liquid crystal is such that in illuminating the plates a high contrast is achieved on the order of 20:1. The chief merit of the liquid crystal displays is the insignificant energy consumption (fractions of a milliwatt per displayed sign), and this makes it possible to power them using small batteries. Among the drawbacks are a certain delay in displaying the information (around 100 microseconds). The resolution of the liquid crystals is two elements per mm. Liquid crystals may also be used not only on large screens but also on individual displays.

Plasma panels are based on the glowing of inert gases with their ionization. Such a panel consists of three transparent plates. The inner plate has openings which are filled with a mixture of neon and nitrogen, and electrodes have been applied to the external plates. The total voltage formed in the area of the intersection of the electrodes causes a process of the ionization of the gas mixture or a halting of it. A merit of the plasma panels is the great clarity and the significant service life. The resolution is two-three elements per mm, and over the long run can be increased by several-fold. Brightness reaches 3,000 nits and the data display lag time is tenths of a microsecond.

The designated technologies can be applied both for developing large screens as well as for individual displays.

The displaying of information in a graphic form and in a printed form will make it possible for the commander to be constantly up on the occurring events, to respond promptly to all changes in the situation and to control the troops efficiently.

An analysis of the present state of ASUV indicates that they have already achieved a high level of development. According to the assertion of foreign specialists, the armed forces in the developed capitalist states could not function without the automated control systems. Great prospects for their development and use are to be opened up in the future. For this reason a methodological analysis of the question of the potential possibilities of man and machine in the process of troop control is so important.

3. Potential Possibilities for Improving Automated Systems

One of the central and most complicated methodological problems in the full automation of troop control systems is to determine the degree of the possibility and necessity of automated the functions carried out by them considering the achievements in the economy, science, technology and military affairs. A solution to this question is related primarily to a methodological analysis of the potential possibilities of improving cybernetic systems. For a clearer notion of this is it possible to examine the following operational and tactical example.

In the course of an exercise or maneuvers held at night on 1 January, a commander responsible for providing cover for a set area had to solve the problem of intercepting enemy airborne targets approaching the defended area. The targets had been detected, their coordinates, speed, altitude, course and other parameters were known, and these were fed into the calculator. According to the calculations made squadron No 1 was in the best situation for repelling the enemy attack.

However, the regimental commander taking the decision knows that in the squadron a month previously the commander had fallen ill, and his deputy had not yet fully mastered the position held. The discipline of the personnel had somewhat weakened. Moreover it was New Year's Eve. The squadron consisted basically of young pilots who had recently mastered the new equipment. Would they be able under such conditions to carry out a combat mission? Wouldn't it be better to alert squadron No 2? In terms of time it would carry out the mission, and it was significantly better prepared in material and moral terms. In truth, if this squadron was alerted, the area covered by it would be correspondingly stripped. A risk? Yes, but a justified one. As was known from analyzing the situation and certain other sources, an attack in the direction covered by squadron No 2 was improbable at present. Thus, the decision was taken.

Could the machine have recommended this or a similar choice? Certainly the commander took the decision considering additional information which the machine had not received. For this reason he was under better conditions. Let us endeavor to put them in circumstances which are relatively equal for solving the given problem. For this purpose it is essential to put into the electronic memory of the machine additional information which was described above. However, in this instance, the researcher must overcome an entire series of difficulties.

First of all, on the various levels of the development of science and technology, any cybernetic system, like man, will possess finite opportunities in terms of the receiving, storage and processing of information. It is essential to clarify just what these possibilities are, and whether they can be equal to or even surpass the capabilities of man.

The broadening of these possibilities always entails a complicating of the cybernetic system, an increase in its size and, consequently, a reduction

in the reliability of its work. The time for processing the additional information is also increased. The time factor, as is known, is one of the most important ones in solving any problem, and particularly a military one.

Thus, on any previously set level of science and technology, in solving a whole series of complicated problems, it is essential to consider the constraits determined by the amount of information which must be fed into the cybernetic system, by the time needed for processing it, and by the reliability in the functioning of the ASU.

In this regard there must be a special and thorough examination of the question of how quickly and accurately can a person carry out these missions.

As is known, computers solve a large class of problems significantly faster and more accurately than man. Ordinarily, these are termed uncreative tasks. Along with them, there are also so-called creative tasks which for one reason or another are inaccessible for machine solving but are successful solvable by man.

The above-examined example could be classified among the creative tasks. However, the decision taken by the commander was based on additional information. If this had been fed into the electronic memory of the machine, it also could solve the problem, and in this manner the problem would then be in the area of the uncreative ones. Here, however, another difficulty arises.

The machine solving of the problem presupposes a formalization of it, that is, the expressing of it in the form of a system of strict formal rules which exclude multiple interpretation. In terms of our problem, it is essential on a strictly uniform basis to "explain" to the machine what New Year's Eve is and what is its relationship or possible relationship to the carrying out of the combat mission, how the command qualities of the deputy regimental commander influence the level of military training and discipline among the personnel, and so forth.

Furthermore, the commander, in taking the decision to alert squadron No 2 and not squadron No 1, consciously takes a risk and thereby assumes all the responsibility for the decision taken. A person who does not possess definite moral qualities in such a situation would possibly prefer not to take the risk. And having chosen the first variation, the commander would provide insurance against possible accusations of stupidity or adventurism. Consequently, it is a question of the possibility of representing in a formalized form a whole series of qualities of a military leader acquired in the process of social evolution.

It is not difficult to note that in the above-given example, fundamentally different possibilities are at work. Consequently, an analysis of the questions of the possibilities of improving cybernetic systems must be made

considering the varying magnitude of these possibilities. In the first place, it can be a question of formal or abstract possibilities, the assumption of which, while not contradictory to the development patterns of nature and society, do not have real bases.

Secondly, it is essential to examine the real possibilities where the conditions for realizing them already exist or can appear in a strictly historically designated stage in the development of science and technology.

The relationship of the designated possibilities has a dialectical nature. The boundaries between them are fluid. At a certain stage in the development of society, a formal possibility can become an impossibility or a real possibility and then reality.

However the mixing up of these philosophical categories inevitably leads to confusion, and does not make it possible to solve the question of the possibilities of improving cybernetic systems with sufficient clarity.

The result of such confusion is both the excessive optimism instilled of the successes of theoretical cybernetics as well as the extremely pessimistic views sometimes voiced in assessing the real technical difficulties confronting practical workers in the attempts to design rather complicated cybernetic systems.

The successful theoretical solution to a whole series of fundamental problems in cybernetics is tied to the extensive use of certain abstractions (idealizations) possessing a rather high degree of commonness. Their incorporation makes it possible to successfully examine the potential possibilities of cybernetic machines. However, the transition from ideal models to real machines requires a weakening of certain abstractions, a reduction in the degree of their commonness or an abandoning of them. All of this gives rise to certain limitations in carrying out the corresponding possibilities.

The concretization of the philosophical concept of formal possibility is the abstraction introduced by A. A. Markov of potential feasibility which "consists in an abstraction from the real limits of our constructive possibilities caused by the limitation of our life in space and time...."[2] On the basis of using this abstraction, the ideal Turing machine was designed. "In the Turing machine, a portion of memory...is displayed in the form of a strip unlimited on both sides and broken up into cells. Obviously, in no real machine could there be an infinite memory (an infinite strip), and in this sense the Turing machine is merely an idealized scheme reflecting the potential possibility of increasing the volume of memory."[3]

Certainly, it would be impossible to actually design a Turing machine. However, formally, from the viewpoint of the abstraction of potential feasibility, it is possible, for the patterns of its functioning do not contradict the laws of nature.

In distinguishing the real and formal possibilities for improving cybernetic systems, it is advisable to examine first of all the arguments in favor of the constraints of the latter.

At present it is possible to consider the skepticism of certain specialists caused by the technical imperfection of automata in comparison with the human brain as overcome. The indications of the purely quantitative aspects of the problem, in being unconvincing on the philosophical level, are contradictory to the technical achievements of today. Undoubtedly as yet it would be very difficult to develop and provide reliability in an electronic machine consisting of 10^{10}-10^{12} elements with sufficiently flexible and complete links between them and with input and output devices the capacity of which would be comparable with the possibilities of human sensory organs. However, many technical difficulties at present are already resolved or are in the stage of being resolved. For this reason, it is possible to boldly assert that the designated differences, in being purely quantitative, at a certain stage in the development of science and technology will be overcome.

However there are not only quantitative but also qualitative differences between the processes occurring in a technical system and the functioning of the brain. Consequently, the solution to the problem of the potential possibilities of cybernetic systems to reproduce various aspects of thought activity is possible only on the basis of the fundamental notions of dialectical materialism on the essence of conscience. The idea of the sufficiently complete modeling of the living, and particularly thought processes, has caused a number of arguments in certain philosophers, and the essence of these questions can be reduced to the following theses.

The physical form of the motion of matter is simpler and inferior in relation to the biological. The latter is characteristic for a qualitatively different state of matter which is defined as living. Thinking is possible only within the limits of the biological form of the movement of matter under the condition of its achieving a sufficiently high level of organization. Moreover, it is not only a function of matter organized in a particular manner but also the product of the sociohistorical development of society.

For this reason the attempts at a more or less complete modeling of thought on a nonprotein level should be qualified as a mechanism, for they clearly represent a reduction of the higher form of the movement of matter to an inferior one.

A logical consequence from such a viewpoint is the conclusion of the impossibility of modeling by technical means any processes whatsoever occurring in the brain and being a property of organic highly organized matter. However the given assertions are not valid since they contradict practice. The simplest digital machine to some degree models one of the mechanisms of the human memory which is a property of organic highly organized matter.

Moreover, it cannot be asserted categorically that the process of a qualitative transition from one form of the movement of matter to another and a corresponding rise in the level of its organization are possible only on the paths of the natural evolution known to us. Obviously transitions from one form of motion to another can be qualitatively different. Natural evolution brings matter beyond the limits of the physical form of motion through chemistry and biology. However, from this it in no way follows that there is no other possibility for such a development. It can be assumed that one of them is realized in technical systems created by man. By this path matter can attain a very high level of organization characterized by no less complexity, diversity and richness of internal relationships than in biology.

Certainly, the substantive basis of the carriers of the forms of motion examined by us differs. However, an assumption of the possibility of modeling the processes occurring in one form of motion in a substratum which is the carrier of another form of motion (under the condition of the same magnitude of the degree of their organization) will not contain any mechanism. Such an approach makes it possible to look differently at the possibilities of modeling thought. To the degree that it is possible to achieve a high level in the organizaition of matter on a different substratum basis than the brain, the real models of the brain and its mental functions are real and sufficiently complete. In other words, in holding the viewpoint that thought, like life, occurs only on a protein basis,[4] and without resurrecting the poorly formulated problem of the "thinking of machines," nevertheless it is valid to speak of the modeling of thought processes on a different substrata basis.

However, in characterizing conscience as a property of highly organized matter, only one aspect of its essence is touched upon. The social causality of conscience operates as the other aspect, and this "from the very outset is a social product and remains this as long as people exist."[5] The founders of Marxism-Leninism repeatedly emphasized that conscience is a product of sociohistorical development, and that the brain does not think by itself, but rather it is social man with the aid of the brain. A cybernetic machine of any complexity is not a social being. It remains merely an unique implement in the hands of the conscious and purposefully acting social being, man. The given concepts of dialectical materialism, although eliminating the problem of creating a "thinking automaton" by the forces of cybernetics,[6] however do not exclude the fundamental possibility of modeling thinking. Its social nature can be understood and correspondingly depicted in the program of a cybernetic machine. On this level, in our opinion, the statement of L. B. Bazhenov is valid. "A machine in no way becomes a social being, but man, having understood and programmed the social causality of thought, reproduces it in the machine," noted the Soviet scientist. "If the social nature of thinking is natural and understandable, then in principle it can be artificially reproduced like the other aspects of it."[7]

Thus, on the philosophical level the question of the formal possibilities of automation merges with the gnoseological problem of the cognizability of the world, and these very possibilities ultimately are determined by the successes of cognition and the precise mathematical-logical expression of the socially determined patterns in the functioning of the human brain.

On the natural scientific level, arguments in favor of the limiting of the formal possibilities of cybernetic systems are often linked to the presence of so-called algorithmically unsolvable problems. As it known there are entire classes of problems for which no single algorithm exists for their solution. Is not the strictly mathematically proven impossibility of algorithmizing certain classes of problems that fundamental limit which determines the area for the action of cybernetic machines?

First of all, the fundamental impossibility of seeking out an algorithm for the given class of problems can mean the absence of a certain type of relations between certain set conditions and the sought result. In such an instance, the given class of problems cannot be solved by singular methods either by man or a machine.

Furthermore, the absence of a single algorithm does not exclude the possibility of solving any specific problem of the given class. Human intellect finds particular instances of solving mass problems which are insoluble algorithmically. However this can also be done by a sufficiently powerful cybernetic machine.

Recently attention of researchers has been attracted to heuristic programming based on the study and use for programming of the methods and procedures used by man for solving problems the algorithm of which is unknown to him. In the opinion of certain authors, the heuristic procedures can be viewed as approximate methods for solving algorithmically unsovable problems.[8]

The simultaneous use of heuristics is caused by the fact that many algorithmically solvable problems remain virtually unsolvable due to the actual impossibility of carrying out the volume of calculations. For this reason the theory of heuristic programming to a certain degree can help to overcome these difficulties.

At present only a few heuristic programs can be mentioned which make it possible to solve a certain limited class of relatively simple problems which are remote from broad practical use. However, even now it is clear that the heuristic search provides an enormous gain in time in comparison with the systematic checking of variations.

At the same time the assertion that "an algorithm does not exist" can mean only the impossibility of seeking it out in the given logical system of knowledge, that is, on a certain level of the development of science, in using modern mathematics.

It may be proposed that with the corresponding broadening of the designated logical system of knowledge the previously "nonexistent" algorithm will be found.[9] If a machine is capable of itself broadening the logical system in which it functions at the given moment, the absence of a single algorithm for solving a certain class of problems is not an insuperable obstacle for it. In broadening the area of formalized knowledge, the machine can find previously unknown relationships (if these exist at all) and on the basis of them make up the necessary algorithm.

For clarity it is possible to give the example of how a machine can "discover" Maxwell's equations independently of man. For this it is merely a question of putting into the electronic memory a description of a series of experiments on electrodynamics and the corresponding class of differential equations. After this the machine itself will select those which best conform to the results of the experiments. In precisely the same manner, with a rather complex system of hierarchically organized self-instructing programs, it is possible to detect the relationships and patterns previously unknown to man. On the basis of them, a computer will supplement and correct its programs and draw up new ones. All of this applies fully not only to the algorithmically unsolvable but also to the algorithmically solvable problems or to the creative problems the algorithm of which, although existing, is however unknown to man. "In complicating the program by utilizing methods already found by the machine in the process of searching for a new method, it is possible to successfully model creative activity on an ever higher order," writes Academician V. M. Glushkov on this question. "In the process of such modeling, it is possible to force the machine automatically to pose new problems for itself and to find their solution."[10]

It is frequently said that the "world of the machine," its "universe," and the "horizons of its vision" are determined by an algorithm and by a program. This of course is true enough. However, these notions must not be understood in a simplified manner by identifying algorithmization merely with a rigidly determined once and for all set and unchanged line of behavior.

Any machine (including a heuristic one) requires a definite mathematical support for its operation. The necessity of ever more complete formalization is caused precisely and primarily by the development and introduction of various computers into control practices. However, is this requirement fundamental for solving the question of the limited nature of the formal possibilities for improving cybernetic systems? The analysis made convinces one that a machine, in possessing a certain program, can extend the limits of formalization and find previously unknown algorithms. In accord with this it is capable of changing and correcting the program used in the machine. Consequently, being limited in its actions by the sphere of normative formalization, the machine itself broadens it.

Thus, neither in philosophy nor in natural scientific research at present are there sufficiently sound arguments in defense of the notion of restricting the formal possibilities for improving cybernetic systems. Bearing in mind the formal possibilities of improving cybernetic devices, on the level of the abstraction of potential feasibility it is valid to raise the question of modeling such clearly complex phenomena of conscience, including the creative processes of thinking using technical systems which correspond to the human brain in terms of their complexity, the diversity of functions carried out and problems solved.

Certainly we are more concerned with the transition from formal to real possibilities which can be turned into reality at any but not infinitely distant stage of development.

A review of the real possibilities for improving cybernetic systems should be started by analyzing the dialectics of the relationship: function--structure--substratum.

There are two interrelated and at the same time in a definite sense opposite directions in modeling the mind. One of them is characterized by attempts to reproduce definite functions analogous to the brain mechanisms. The other direction is aimed solely at reproducing the functions regardless of the mechanism of their realization. A researcher of the second direction will be satisfied if the machine will effectively perform one or another complex problem of data processing. An experimenter who prefers the first direction will be satisfied if the machine solves the problem by the same method as man. For the former, the identicalness of the results is of great significance, while for the latter, the nature of the process is equally important.

The first direction which is related predominantly to the functional approach can be defined as the cybernetic or functional modeling, and represents the cybernetic aspect of elaborating the problem of an "artificial intellect." The second direction is based mainly on the data of psychological and neurophysiological research and to a greater degree uses the structural analogies considering the known structural characteristics of the modeled systems.

Regardless of the designated difference, both approaches are interrelated. In actuality, if the method is known by which the brain solves a certain data processing problem, then an opportunity is provided for creating a program with the same logic making it possible for the machine to solve this problem analogously to man. At the same time, the presence of a program for solving certain problems may suggest the method of solving similar problems by man.

In this regard there is particular interest in the assertion of specialists that there is an isomorphic nature of the work of machine and man in solving the problems of image recognition.[11] At the same time, a series

of psychological research has experimentally shown that the nature of the processes of seeking the solution to one or another problem by a cybernetic system and man, regardless of a definite similarity as a whole, significantly differs.[12] All that has been said characterizes the unique manifestation of the dialectical relationships between structure and function in complicated dynamic systems. The possibility and necessity of a functional approach to their examination are caused by the fact that functions possess a certain independence in relationship to structure, they are linked to it indirectly, and this very relationship is not rigid and uniform. Nevertheless, "a definite function is performed not by any structure generally, but only by any structure taken from a certain limited 'class of structures' all the elements of which contain certain necessary common properties."[13]

Structural analogies can be very distant in modeling one or several functions. Here, along with the limiting of some functions, others which are very important and even crucial in one or another area of activity can be sharply strengthened. The history of human progress knows many examples when the best results were achieved precisely due to the abandoning of precise structural analogies with living organisms.

And in a similar manner the operations carried out in a computer differ from those occurring in the human mind. The structures of the systems carrying out these operations differ substantially. Precisely because of this modern computers greatly surpass the human brain in terms of the speed and accuracy of calculations. In principle it is possible to create a program which imitates the customary method of arithmetical calculations for man, but it is extremely ineffective.

However, an increase in the number of modeled functions or their complicating imposes ever more rigid constraints on the structure of the systems modeling these functions. Obviously the greater the number of functions of one system which is reproduced simultaneously by another system, the more complete their similarity of structures should be. A disconformity of structures entails functional constraints. In any event it is indisputed that the modeling of a certain set of functions necessitates a corresponding level of complexity in the structure of the modeling system. Here it is a question not so much of physiological structures as it is of informational structures.[14] Precisely this aspect of the question has been pointed up by the well known Soviet scientist P. K. Anokhin, in noting that in terms of individual parameters of the human brain and its activity it is possible to develop more advanced machines, however the accent must be put not on individual capabilities, but rather on the interaction of these abilities and the moves from one to another.[15]

At the same time, since the relationship between the structure and substratum of any system is a concrete expression of a dialectical relationship between form and content, to this degree structure has only a relative independence. Consequently, the difference of the substrata to one degree or another is also reflected in the nonidenticalness of the structures.

The question arises whether it is always possible to establish a definite congruity of structures with a differing substantive base, that is, to detect or design those elements (substrata) of the system which would make it possible to provide the isomorphism (or in the general instance, homomorphism) of the modeled and modeling structures on a level sufficient for the reproduced function? It must be pointed out that modern science is still very far from solving this problem not only on the practical level but also on the theoretical one. For this reason, a further thorough investigation of the phenomena of life precisely from the aspect of its substratum may provide a negative answer to this question. Thus it may seem that certain structures and thereby the entire group of living functions cannot be reproduced in any way but on a protein level. That is, at a certain stage the corresponding constraints will be discovered. Nevertheless the attempts at relatively complete modeling of thinking using various cybernetic systems are not only valid but also essential, for in the process of experimental search alone can any limiting patterns be discovered if such exist at all.

Thus, the first difficulty in moving from formal possibilities for modeling thought to real possibilities is related to the necessity of artificially creating that material formation the structural organization of which would be comparable with a biological one in terms of the richness of internal ties and relationships. And the question of the fundamental possibility of achieving such a high level in the organization of matter on any other substratum basis than the brain itself is far from resolved.

The second and equally complex problem on the path of realizing the potential possibilities of modeling thought is related to the discovery and accurate description of the patterns of the functioning of the brain considering the social causality of these patterns. The solution to this requires efforts from the entire aggregate of the sciences studying the essence of thought, the structure and organization of the brain, its functions in the process of processing information as well as the development of the corresponding mathematical logical apparatus which would be capable of reflecting with sufficient completeness and accuracy the patterns of brain functioning in a formalized form making it possible to create algorithms and programs.

Dialectical materialism views conscience as a definite property of highly organized matter and a product of sociohistorical development. "...Our conscience and thinking," wrote S. Engels on this question, "however supersensitive they may seem, are the product of a physical, corporeal organ, the brain."[16] Conscience does not entail anything supernatural, incomprehensible or in principle inaccessible for study. The Marxist-Leninist methodological notions of the fundamental cognizability of the world provide reason to assert that in certain stages of the development of science and social practice this property of highly organized matter has been rather fully studied. The patterns of the functioning of the brain, including the social causality of thinking, will be understandable and

describable to an ever greater degree of accuracy, and in accord with this the possibilities for modeling thinking on each historical level will be broadened. However, one must not forget the following. In the first place, modern science is only on the distant approaches to solving these problems, and secondly, in the course of the corresponding research (as in an attempt to achieve a high organization of matter on a nonprotein base), certain limiting patterns may be discovered. For example, it may turn out that the number of rules for processing information by the human brain is infinite.

Moreover, for creating systems of machines the functional efficiency of which in all regards could be compared with the efficiency of human activity, it is essential to formalize and turn over to the cybernetic system all information acquired by mankind as a result of the millions of years of biological and social, sociohistorical development. To the degree that this information is incomplete, the real process of thinking will differ from its model not only structurally but also functionally.

The comment made by Academician A. N. Kolmogorov in a joking form of "possibly an automaton capable of writing verses on a level of the great poets cannot be constructed more simply than having modeled all the development of the cultural life of a society in which the poets actually developed,"[17] thus acquires profound meaning.

In analyzing this statement, B. V. Biryukov and Ye. S. Geller correctly emphasize that "for this it is essential to model the 'logic of history,' to model the historical heritage in the area of the content and methods of thinking which are assimilated by an individual entering life. And this means to model the path of development of a modern individual and to 'supply' the corresponding 'model' with the needs of real social individuals, including ethical, aesthetic requirements with their biological prerequisites and social content."[18]

At any historically determined stage in the development of cognition, there exist an area of formalized knowledge and an area of unformalized knowledge which encompasses it. Both these areas are being constantly transformed. The boundaries between them are mobile and historically changeable. In precisely the same manner that in the objective world there is nothing that is in principle incomprehensible but merely not understood, in the process of the cognition of this world there is nothing in principle that is unformalizable but merely unformalized. However, the sphere of formalized knowledge always lies within the unformalized. The real possibilities of improving cybernetic systems at any specific stage of development are rather strictly confined by the limits of the area of formalized knowledge. These limits over time can be extended, but a computer in principle cannot go beyond them. But a person not only extends the sphere of formalized knowledge (including by the aid of machines) but also goes beyond its limits. He functions efficiently in the unformalized sphere, using the intuitively informative possibilities of thinking. And

this, in particular, is one of the fundamental advantages of man over cybernetic systems of any complexity.

At any, however distant stage in the development of a society its scientific, technical and economic possibilities are not unlimited. And correspondingly the real possibilities for improving cybernetic machines, their technical, informational and material support are limited by definite specific historical limits. At the same time it must not be forgotten that the mental abilities of man are constantly developing, including by using cybernetic equipment. Consequently, there will always exist a rather broad class of problems the machine solution to which is impossible or ineffective. Under the same conditions, a person, in using unformalized knowledge, in making reasonable assumptions and in using less strict methods, can solve these problems comparatively simply and with sufficient accuracy. Thus, at any stage in the improving of cybernetic systems, the dominant and leading position of man in relation to them will be maintained.

The methodological analysis given above makes it possible to conclude that along with progress in science, technology and military affairs, the real possibilities for automating troop control will constantly grow. At the same time the functions of the personnel which in one way or another is involved with automated control systems will be broadened and enriched. In actuality, the achievements of the present-day scientific and technical revolution and the revolution in military affairs even now make it possible to algorithmize and prepare a number of control problems for machine solution. At present the automation of the control process encompasses not only the sphere of mathematical calculations, but also such functions of control organs as the selection and classification of information, its display, a comparison of the existing combat situation with a previously known one, and the exchange of information within the controlling body. Certainly the carrying out of these functions in part does not require a creative approach and is comparatively simple, monosyllabic and already technologized in the human brain. For this reason all these operations can be precisely described and realized using automatic devices.

Along with them, the process of troop control includes such procedures as evaluating information, discovering the plan of the enemy and a final selection of the variation of the decision.

The carrying out of these requires a creative approach, a dialectical flexibility of thinking, social stimuli, and an emotional uplift, that is, qualities in herent only to the human intellect. As was pointed out above, their precise formalization can be recognized as only potentially possible.

For this reason, the aim of automation is not to replace man by a machine, but rather to bring about a maximum rise in the efficiency of control activities and the combat possibilities of the troops. Such a complicated problem is solved by setting up control bodies which include collectives

Such systems have been named "large systems" of the "collective--machine" type. In automated systems the shortcomings of man and cybernetic machines are reciprocally compensated for, and their merits are maximally divulged and emphasized. They in the best manner combine speed, accuracy and precision of automata with the flexibility and diversity of the mental, physiological and social qualities of man. This becomes possible only with a rational allocation of control functions between the machine and man. In our opinion, the embodying of the real possibilities of full automation in reality in any interval of time requires the formalization of the investigated area of troop control and certain processes of mental activity related to the processing of information, as well as the availability of the technical devices for realizing the formalized moments of creative activity. Considering these general methodological concepts it is essential to approach the analysis of the present state and development prospects of automated troop control systems.

FOOTNOTES

1. The research on the questions of the given section has been carried out using the examples of the development and organization of automated troop control systems in the United States. Here use has been made of materials published in open foreign sources.

2. A. A. Markov, "The Theory of Algorithms," "Trudy Matematicheskogo Instituta imeni V. A. Steklova" [Works of the Mathematical Institute imeni V. A. Steklov], Vol 42, Moscow-Leningrad, 1959, p 15.

3. V. A. Trakhtenberg, "Algoritmy i Mashinnoye Resheniye Zadach" [Algorithms and the Machine Solving of Problems], Moscow, 1957, pp 60-61.

4. At present there are hypotheses on the possibility of life and thought on a different substratum basis. For example, Yu. V. Orfeyev feels that "dialectical materialism cannot help but recognize the fundamental possibility of the existence of life on a nonprotein substratum." See Yu. V. Orfeyev, "Mental Labor of Man and Machine Thinking," "Nauchnoye Upravleniye Obshchestvom" [Scientific Management of Society], Moscow, 1970, p 336.

5. K. Marx and F. Engels, "Soch.," Vol 3, p 29.

6. The authors of the present work agree with the viewpoint of a number of Soviet and foreign Marxist philosophers according to which: "Only all sciences taken in their dialectical unity and in the closest tie to social and scientific experimental practice can lead human thought to the greatest victory, that is, to the creation of not simply a protein or other similar substance, but a living, thinking and purposefully acting being." ("Leninskaya Teoriya Otrazheniya i Sovremennost'" [The Leninist Theory of Reflection and Modern Times], Moscow-Sofia, 1969, p 20.)

7. "Filosofiya Yestestvoznaniya" [The Philosophy of Natural Science], No 1, Moscow, 1966, p 378.

8. Yu. V. Orfeyev, "Heuristic Programming and Certain Aspects of Control Theory," "Nauchnoye Upravleniye Obshchestvom," No 1, Moscow, 1967, p 276.

9. This supposition is based, in particular, on Hödel's theorem, the essence of which is as follows: within any sufficiently developed formal system it is possible to formulate a thesis not proven in it as well as its negation. Here it is possible to broaden the system of formalism axioms in such a manner that the sought proof will be found. Then at least one supposition not presently proven in the extended formal system will be discovered without fail, and so forth.

10. V. M. Glushkov, "Thinking and Cybernetics," "Dialektika v Naukakh o Nezhivoy Prirode" [Dialectics in the Sciences on Inanimate Nature], Moscow, 1964, p 517.

11. N. S. Sutherland, "Human-Like Machines," "Chelovecheskiye Sposobnosti Mashin" [Human Abilities of Machines], Moscow, 1971, p 25.

12. O. K. Tikhomirov, "The Heuristics of Man and Machine," VOPROSY FILOSOFII, No 4, 1968.

13. B. A. Glinskiy, et al., "Modelirovaniye kak Metod Nauchnogo Issledovaniya" [Modeling as a Method of Scientific Research], Moscow, 1965, p 138.

14. See B. V. Biryukov and Ye. S. Geller, "Kibernetika v Gumanitarnykh Naukakh" [Cybernetics in the Humanities], Moscow, 1973, p 132.

15. See P. K. Anokhin, "Problems of Modeling Living Processes and the Physiology of the Brain," "O Sushchnosti Zhizni" [On the Essence of Life], Moscow, 1964, p 206.

16. K. Marx and F. Engels, "Soch.," Vol 21, pp 285-286.

17. A. N. Kolmogorov, "Life and Thought as Particular Forms of the Existence of Matter," "O Suchchnosti Zhizni," p 57.

18. B. V. Biryukov and Ye. S. Geller, "Kibernetika v Gumanitarnykh Naukakh," p 113.

CHAPTER 4: SPECIFIC METHODS FOR AUTOMATING AND OPTIMIZING TROOP CONTROL PROCESSES

1. The Modeling Method and Its Role in the Automation and Optimization of Troop Control

The theoretical examination and practical solution to the problems arising in the area of troop control necessitates the use of an entire armamentarium of scientific methods. Moreover, the complex nature of the control systems and processes necessitates the use of a systems approach to their study and the integrated application of diverse methods.

The principles of materialistic dialectics hold the fundamental role in the system of employed methods. They demand the consideration of the diverse ties and processes in developing troop control systems, objective, concrete and thorough research, the elucidation of the internal and external contradictions, unified analysis and synthesis, informative and formal, quantitative and qualitative approaches in solving the scientific and practical problems in the sphere of troop control.

However, the general methodological principles do not exhaust the cognitive means needed for solving such a complicated problem. Within these means it is essential to include the general scientific methods of imperical and theoretical cognition. The defined forms of observation, experimentation, and sociological investigation are organically linked with logical operations of analysis, synthesis, abstraction, formalization, idealization, and so forth. They are applied on the basis of the natural and model, quantitative and qualitative approaches. The systems approach and systems analysis of troop control processes are the unique collecting link which determines the specific method of using all these means.

In its content, systems analysis links the universal method of dialectics with the methods of special sciences. A systems approach has two aspects. Its essence is expressed, in the first place, in a definite understanding of the very object precisely as a whole system interacting with other systems, and secondly, in the interpretation of the research process as a systems one in terms of its logic and the applied means. It in a way

concretizes in terms of the particular tasks the initial concepts of dialectics on the necessity of viewing any object as a unified developing whole consisting of interrelated parts and interacting with other objects and with all objective reality. It realizes the dialectical principles of objective, thorough and concrete research, the unity of analysis and synthesis, and the unity of all empirical and theoretical means of research. The use of modeling, formalization, the mathematical methods of operations research in the process of automating and optimizing troop control must also be viewed from this standpoint.

The improving of the systems and processes of troop control includes the solution to two fundamental problems. In the first place, the creation of the necessary conditions and technical means which ensure high efficiency of control processes, particularly the working out of a decision and the planning of combat as the most difficult and requiring great outlays of time. In the second place, a rise in the efficiency of control actions, and above all in the soundness and accuracy of the decision taken.

The basic ways for solving these problems lie in the automting of control processes, the elaboration and application of scientific bases and quantitative and qualitative methods for optimizing control actions. Automation and optimization are profoundly interrelated processes, for it is obvious that a rapidly taken but incorrect or ineffective decision is just as undesirable as a correct, even optimum decision but one not promptly taken. The solution to either problem both separately and in their unity is inconceivable without using modeling in its various forms and varieties.

In examining the role of this research approach which is widely used in modern science and practice, it is essential to elaborate definite views on at least the following questions:

1) Why is it essential to use modeling in the various stages of research and development of automated control systems and in the different stages of working out and optimizing combat decisions?

2) What processes should and could become an object of modeling and what are the possibilities for constructing their models?

3) What types of models can be used in solving automation problems and in the interests of optimizing control?

The answers to these questions depend upon one or another understanding of the essence of the method of models. For this reason, it is essential first of all to clarify the notion in which the concept "model" and "modeling" are used.

Recently the greatest attention has been given to the modeling method both in the sphere of elaborating its special theory and applications, as well as on the level of philosophical and methodological analysis. The essence of modeling, its objective prerequisites, the classification of models and their gnoseological functions have been examined in a number of works.

The overall evaluation of many views is that a model is an analogue or imitation of reality, that is, an object (process) similar in certain regards to other objects (processes). The similarity (homomorphism, isomorphism or isofunctionalism) of two phenomena is a necessary prerequisite in order that one of them can become the model of the other. Actual combat and troop exercises, a topographic map and a portion of the terrain, field firing and a system of equations describing this, the brain and the computer possess an objective similarity in certain regards. Under certain conditions this makes it possible for them to act as models of one another.

However, the similarity of two objects (processes) is not sufficient for one to actually become the model of the other. On the theoretical and cognitive level, one of two similar systems can be viewed as the model of the other only when: a) it actually assumes the functions of the replacement of the other system; b) as such it becomes an object of direct investigation or practical operation; c) is used as the principal of cognition and action (of a third, modeling system)[1] as an implement for systematizing known information on another system and for gaining new information.

For example, combat and troop exercises, regardless of the similarity in a number of features, do not operate automatically as the original and the model. The independent processes in the given instance can also be examined independently of one another. However, exercises become models with their conscious use as an analogue of a certain type of combat, and operate as a means for systematizing the known information about this and for gaining new information. On the other hand, real combat (the most typical instances) can serve as a model in working out the overall concept and plan of the corresponding exercises.

Considering what has been said, a model can be defined as a systems object A having a similarity in certain definite regards to the systems object B and serving for the principal of cognition (the modeling system) as a means for fixing known information about object B or for obtaining and transforming new information about this.

Correspondingly, modeling is the reproduction of one object or process (the original) using another (a model) or the constructing (finding), examination and use of models. The subject of modeling "can be concrete as well as abstract objects, both actually existing systems as well as systems which are merely to be designed...."[2] As a rule, with the aid of models, complicated, inaccessible or expensive objects and processes are reproduced and studied indirectly. Other objects which exist or are specially created and which may be physical or conceptual or symtolic may act as their models.

Being a scientific method, modeling incorporates a series of sequential operations: The selection from existing objects or the artificial constructing of an object capable of performing the functions of a model; theoretical investigation or practical testing of the model for the purpose

of disclosing the fullest possible information on its properties; the transferral of the obtained information from the model to the original on the basis of certain methodological concepts and logical rules.

The stated understanding of a model and modeling makes it possible to answer the question of what the necessity of them is in solving the problems of automating and optimizing troop control. This is determined by those common functions which models can perform and actually do perform as a means of scientific research.

At the empirical stage of research, a model (or a model experiment), on the one hand, serves as one of the sources of the initial factual data and as a means for the preliminary processing or systematizing of these data, and on the other, acts as an instrument for the intermediate or indirect testing of the results of theoretical research, that is, within definite limits performs a criterial function.

In the theoretical stage, the use of models makes it possible to describe strictly the examined phenomenon, to depict it in a generalized, schematic or symbolic form. Here the phenomenon can be explained, having represented the complex by the simple and the unknown by the known. It is possible to go on to a quantitative analysis and to forecasting possible changes in the studied phenomenon with the influence of various factors on it, as well as determine the necessary changes in the studied phenomenon, that is, to prepare and ensure its control.

All these general functions are concretized in analyzing the methods for applying models in the interests of automating troop control. First of all it is essential to point out that in principle modeling makes it possible in a more correct, economic and relatively faster manner to solve the involved problems of studying and working out automated control systems.

Often it is necessary to develop fundamentally new technical systems with an insufficiently developed theory for the processes to be reproduced and very limited experience in designing such systems. The newness of the problem and the presence of undetermined factors also cause definite difficulties. The use of models to some degree makes it possible to surmount these difficulties, to have a clearer notion of the problem being solved, to feel out a correct direction of work, to obtain and test certain data, and at the same time to acquire the necessary experience in designing, and to generalize the theory for constructing and the functioning of control systems.

Since it is a question of developing not only complicated but also very expensive systems, the search for the best variations of these systems by the trial and error method in a full-scale experiment is completely unacceptable. The use of models increases the economy of development for both individual technical devices as well as an automated system as a whole. The obtaining and testing of intermediate results using models

make it possible to discard certain unpromising directions of work and to shorten the distance from the idea to its complete realization.

Finally, modeling makes it possible to also respond to the time factor. The exacerbation of contradictions in the sphere of troop control under the effect of the present-day military and technical revolution as well as the necessity of constant and high troop combat readiness necessitate an acceleration of work in the area of automating control. The rational utilization of modeling procedures reduces the time of all the stages in the research and development of automated systems.

On a more specific level, models, in the first place, create the necessary prerequisites for a thorough analysis of complex systems. For example, as is clear from foreign sources, the development of automated control systems of the Fieldata, Armydata and other types could not be carried out as an isolated task. In the given instance it was essential to consider the goals, structure and functions of both the more general, superior control system as well as the individual subsystems and elements of the systems being designed. It is essential to consider a multiplicity of interrelated factors. Consequently, even the first step of analysis presupposes an integrated and if possible visual notion of the problem and the system itself, its schematization and within acceptable limits, also simplification. The aggregate of the designated operations is achieved using models which in the form of a description, block diagram or scenario reproduce the system on various levels and in different aspects, and interrelate the goals of the system, the means of achieving them, the external conditions for the functioning of the system and the expenditures on its development.

Secondly, models also operate as a direct implement or instrument of analysis itself. As is known, a model can be developed and detailed. From informative, qualitative and schematicized descriptions of the system as a whole it is possible to move on to a strictly formal, quantitative analysis of individual subsystems, elements, and processes of the troop control system. Models in the forms of tables, schedules, control systems and algorithms open up the way to solving problems using mathematics.

Thirdly, in all the intermediate stages as well as at the end of the entire ASUV research and development process, models are a necessary means for checking the results of testing of both the individual elements as well as the entire system as a whole. At the same time, the models (in the given instance it is a question of physical models) provide additional data for posing new tasks aimed at the further development and improvement of the ASUV. The necessity of using models for the purposes of optimizing control and establishing the decisions taken is caused by these same circumstances. The basic aim of optimization is to ensure the elaboration of not only a correct but also the most effective decision or effective plan making it possible to carry out a combat mission in the best manner, that is, within the shortest time and with the least expenditures of forces

and means. For this it is essential, on the one hand, to evaluate the variations of the decisions using mathematical methods, and on the other, when possible to subject them to a preliminary practical test.

However, the complexity of a combat situation and the missions to be carried out, as well as the ambiguity of many characteristics of combat prevent the direct application of quantitative methods. The need arises for such anticipating operations as the schematization of the object, a precise and if possible visual graphic or mathematical logic depiction of it, the formalization of the very problem, the defining of the criterion of effectiveness, the parameters influencing this criterion, the basic constraints, and so forth. All of this requires the constructing and examination of the corresponding models of combat.

It is desirable to test the basic variations of the decision and the plan by practice. However, their comparison and selection in the course of combat itself are virtually impossible. This circumstance also forces one to follow the path of modeling and to carry out the corresponding forms of a model experiment. But what objects (processes) should be modeled in solving the problems of automating and optimizing troop control and what are the possibilities for constructing their models?

The very aim of automation which is to increase the efficiency of troop control by having technical devices carry out the most labor intensive operations in the control process which require great time expenditures indicates the basic objects of modeling. These are the operations of the control process, that is, the specific and primarily mental actions of people (commanders, officers or control bodies) related to the cognition and reflection of the combat situation, the elaborating of a decision and the planning of combat. Ultimately in solving this problem, the organs of perception and the brain, the organs of speech and human hands in one way or another become the objects of the modeling.

Since among the control operations the most important are the working out and optimizing of a decision which presuppose an evaluation of the situation and determining the methods of action in it, to this degree (both within the line of automation and independently of it), the most important objects of modeling are the combat situation, the course of combat, and the processes related to their preparation, execution and support.

If it is a question of just scientific research on the designated objects or an understanding of the general, essential or natural in them, then their relationship with the corresponding models appears as follows. The object of modeling is the already existing reality or the original prototype; the model is an analogue secondary in relationship to it, a mental or material depiction, or a reproduction of the prototype for the purpose of understanding certain unknown characteristics of it.

But when research is combined with creativity, with the designing of new objects and the reproduction of processes or with the planning of own

actions, then the relationship of "original--model" becomes more complex. Not only existing but also future reality is the object of modeling, and this, in our opinion, could be defined as the original teleotype (from the Greek "teleos"--result, conclusion or aim) which embodies the goal of creative activity (the designed technical device or the planned course of combat). In relation to such an object, the model operates as the prototype making it possible to forecast its characteristics, to optimize them or control them.

However the primacy of such models in relationship to the original is a relative one. A model is an intermediary between two types of originals. In reproducing the most essential or typical features of a certain class of known phenomena (prototypes), it anticipates the creation of a certain new variety of this class of phenomena (the teleotype). Here the model which depicts the prototype and the model which is the prototype of the teleotype can not only coincide but also differ. Most often the intermediary is the series of models which in a varying way combine the features of the depicted and designed phenomena. Moreover, through a series of transformations they approach the original teleotype and in individual instances change into it as in the working model of the prototype original.

The prototype original has the primary determining influence on the formation of the model. It acts as its objective prerequisite. A model should first of all embody information on the previously existing (presently existing) objects and processes, and serve as a means for broadening knowledge about them. Only on this basis can the model also embody the traits of the original teleotype. The latter has a formative influence on the model, as a goal to which the model should strive, and as an image of desired future reality.

In the process of automating troop control, the necessity arises of the multistage modeling of future technical devices which should carry out certain operations of the control cycle. For this it is essential first of all to consider and embody in the models the traits of real control operations and the activities of people carrying out the designated operations. Among the basic operations of the control cycle one could put:

1) The collection and seeking out of initial and monitoring information on the elements of a combat situation and the processes of its change;

2) The transforming of the information into a form suitable for transmission and receiving over communications channels, for its storage and use;

3) Transmission, receiving, storage and the putting out of initial, command and control information on the changes in the combat situation;

4) The visual display of this information in a written, graphic, physical or symbolic form;

5) Analysis, generalization and evaluation of the information (an evaluation of the situation) using qualitative and quantitative methods;

6) The formulating of a plan of action, hypothetical variations of actions in the existing situation, and their visual display;

7) Analysis and comparison of these variations, the forecasting of their efficiency, and the carrying out of operational and tactical calculation;

8) The taking of the final decision and the detailed planning of combat;

9) The execution of control actions, the supervision of their fulfillment, and the correcting of the taken decision and plan of action.

What are the possibilities for modeling such processes? Analysis indicates that in terms of the character and degree of complexity, these processes can be divided at least into three groups.

The processes of the first group do not have a specifically mental character. They are subordinate to physical laws which are common to any informational process. For example, these are the receiving and collecting of information, the receiving and transmitting of it over communications channels, and in part its transformation in the form of coding, decoding and a visual display in a sign or symbolic form. A majority of these processes can be modeled and is technically embodied in the work of the corresponding devices, including: Information sources, photographic and movie equipment, means of communications, coding, copying and display systems.

The third group of processes includes thinking operations which express mainly a formal logical, machine-like aspect of it. These include: Comparison, generalization, the transformation of information according to strictly determined formal rules; the solving of logical and computational problems, operational-tactical calculations needed for evaluating the situation and decision taking. The models of such operations are created in the form of algorithms and programs for solving the corresponding problems, and are technically embodied in the work of universal computers using these programs. The modeling of formological operations is being developed and is becoming more and more complete and diverse along with the improving of computers, machine languages and the programming equipment and methods.

The third group of processes is related to the area of the higher abilities of thought, to its heuristic and creative acts. These processes are determined by the laws of not just logic but also psychology of thought and the laws of heuristics. Among these processes are: The very evaluation of the situation, the forming of the plan of actions, the taking of the decision and the planning of actions, and the correcting of the taken decision in the course of combat. These are inseparably linked with conceptual perception of reality, to the work of memory and imagination, to intuition and to constructive-creative, productive thinking. The possibilities of modeling such processes also determine the possibilities

(degree or completeness) of automating control activities. At the same time, the modeling of precisely these processes is of particular interest for philosophy, since it touches upon the question of the essence and functions of conscience.

The final solution to the problem of creating working models for the higher functions of conscience is possible only in the course of attempts to solve it, and in the process of discovering the laws for the functioning of the brain and the constructing of ever more complex models of it. The complexity of the full modeling of the higher functions of conscience requires the construction of their partial models and the reproduction, for example, of the heuristic abilities of thinking and the process of creativity in its various manifestations. Such models are being created and it is even possible to speak of certain advances on this level.

For example, in automating certain processes of control activity, the necessity arises of modeling the image perception of information and the identification of images. Only under this condition can a machine isolate information directly from the tables or diagrams proposed to it or from written and oral speech. As it has been learned, it is not only difficult but in a number of instances still impossible to teach a machine to recognize an object from different distances and aspects, to distinguish one printed or handwritten sign from another, or to determine the meaning of a word placed in differing context. Even here the heuristic, creative possibilities of thought are apparent. Nevertheless the models for the partial solution to such problems at present have been created and the possibilities of improving them are gradually becoming apparent.

Image recognition and many other mental problems are determined by the specific features of the human memory. For example, the retrieval and reproduction of required information by ordinary computer programs are done by the method of running through all the memory cells until the needed information is retrieved. At the same time, man does this work differently, more economically, considering the semantic relationships between the elements of knowledge, and utilizing the associations of perception and heuristic methods for retrieving the information.

Ultimately both image perception and memory are aspects of a single process of creative thought. In line with the necessity of automating the labor intensive preliminary work of evaluating the situation and working out a decision, the task has been raised of modeling the process of situation evaluation, forecasting the changes in the situation, working out variations of decisions, their comparison and the determining of the optimum. The processes of creativity and the heuristic search for the best solution in a problem situation are now the subject of study of both gnoseology, psychology, logic and cybernetics. A promising area of research has appeared: heuristics and heuristic programming. Game theory methods, the methods of the theory of decision taking and deductive heuristics are being worked out and employed for research and modeling creative thinking.

In line with automation and independently of it (since the necessity arises of optimizing decisions taken by the ordinary method), important objects of modeling are:

1) The combat situation and the change in it (the course of combat);

2) The ideas and plans of the sides underlying the existing combat situation and its possible future changes.

Their models, in embodying the typical traits of combat or an operation at the present historical stage of their development and the specific characteristics of the existing combat situation (the prototype original), make it possible to look ahead, to evaluate and in a certain sense determine the possible course of future combat (the teleotype original).

Since it is a question of modeling material and physical processes, this can be more diverse and less complicated to carry out at least in its individual varieties. Certain forms for the models of these processes were used at the dawn of the development of military art. Since the conscious actions of people and the control activities of the enemies are organically incorporated in these processes, their correct and sufficiently complete embodiment in the technical models encounters the same difficulties as in modeling mental control activity itself.

What types of models could be used in solving the problems of automation and in the interests of optimizing control? For answering this question it is essential to describe the basic types of models used in scientific research and to classify them.

As is known, the most important functions of models are related to the obtaining and use of information. For this reason, as the basis of classification it is possible to propose, in the first place, the difference in the content and nature of information on the original, and secondly, the diversity of forms in which this information is represented in the model.

The first basis makes it possible to establish primarily the substrative, structural and functional models. Substrative models must reproduce the material of the original, and provide knowledge on its particular features and properties. Thus, the plasma obtained under laboratory conditions can serve as a model in studying the properties of stellar matter. However, in a pure form this type of model is rarely used. It least discloses the specific features of the modeling method. Structural models reproduce not the material of the original but rather its structure. Typical examples of structural models are diverse mockups, topographic maps, diagrams, and so forth. They can be made from any material or constructed on paper, but without fail they should fix the inner or external form of the original, and the aggregate of relationships between its element. A functional model should reproduce the actions or behavior of the original, that is, its functions. Thus, while models of the first and

second types can be static, the latter must be working models (for example, computer-realized models).

Modeling practices indicate that the designated types of models, as a rule, are employed in various combinations. This makes it possible to distinguish between: a) Models of a unidimensional analogy, when the substratum, structure or functions of the original are reproduced individually; b) models of a two-dimensional analogy making it possible to create substrative-structural, substrative-functional or structural-functional models; c) models of multidimensional or complete analogy which reproduce simultaneously both the substratum, the structure and functions with more or less completeness and detail.

A classification by form in which the information of the original is embodied in a model presupposes two basic types of models: physical and mental or symbolic. These two trunks produce not only a multiplicity of branches but also show a tendency toward a certain intertwining or interpenetration. This is observed particularly clearly in modeling using universal computers.

Physical models are divided into natural models which are true, natural objects and processes performing the role of models because they operate as typical examples of a certain class of phenomena; seminatural models which combine natural and artificially created elements, for example, experimental troop exercises, research military games, and so forth); artificial, technical models represented by physically and geometrically similar devices, by electric equivalent circuits and by analogue and digital computers.

Conceptual or symbolic models include two basic varieties: the descriptive logical models which are an aggregate of visual ideas, concepts and judgments from which a generalized, schematic or hypothetical image of the studied object is formed (the given image can be objectified in the form of a description, drawing, diagram, map and so forth) and the mathematical logical models which are a further development of the descriptive logical ones. These, as a rule, are formular dependences, systems of equations, and diagrams reflecting not only the qualitative but also the quantitative aspect of the examined processes. These would include also the algorithms and programs by which the physical and conceptual processes are reproduced on computers.

Cybernetics has given rise to and actively uses a special form of modeling, the cybernetic models which embody certain traits of the above-mentioned types of models. A general description of cybernetic modeling has been given in the works of the founders of cybernetics N. Wiener and W. R. Ashby. It has also been developed in the works of the Soviet scientists V. M. Glushkov, A. I. Berg, I. B. Novik and others.

When cybernetic modeling is established as a particular form, then in some instances the accent is put on the nature of the reproduced processes, and in others, on the very method of modeling. Obviously, in the given instance it is essential to consider both these aspects equally. Cybernetic modeling is employed primarily for reproducing "large systems," and particularly control systems with the typical attributes for them: Complexity, dynamicness, relative stability, purposefulness of functioning, and the presence of an information process, direct links and feedback between the subsystems.

At the same time, cybernetic modeling is a special method for reproducing the above-named systems. Cybernetics as far as is possible abstracts itself from the substratum of the modeling systems and within the limits of the necessary and possible reproduces their structure, but pays basic attention to the functions, in endeavoring to reproduce in the models the behavior of the system (outputs) depending upon the various effects on it (inputs). Predominantly a functional approach is one of the specific characteristics of cybernetic modeling.

Cybernetics uses various types of physical and conceptual, symbolic modeling, but the specific features of its approach are most of all apparent in the creating of artificial, technical models, that is, cybernetic devices, and particularly electronic computers by which the functions of living or social systems are reproduced.

Finally, cybernetic modeling is mainly information modeling which includes a strict description of the studied systems, the construction of algorithms and programs, and the processing of information on the studied objects (processes) using these programs and a computer. In processing information on the original using the laws of its functioning, a computer within certain limits is likened to the original, and in informational terms reproduces its functions and the results of functioning.

A general description of cybernetic modeling makes it possible to assert that precisely the given form of modeling should play the decisive role in the automation and optimization of troop control. In actuality, it is impossible and even absurd to copy the physical substratum of the human brain and sense organs which carry out control actions. There is also no need to have an obligatory structural similarity of the technical devices to the organs of the human body or the staff departments. Of significance primarily is the reproduction of control functions and various operations related to information processing; the creation of technical devices capable of achieving in the process of functioning the same results as could be achieved by a man solving control problems.

Here, naturally, a major role is played by modeling in its information form. Its essence is that the individual functions of people engaged in a control system are described in ever greater detail, they are subjected to formalization, they are broken down into their component elements, into the elements of these elements and so forth, that is, they

are transformed into an algorithm, into a program of consecutive actions. These programs also form the "soul" of a cybernetic device and a universal computer. The operation of a computer using such a program represents the information modeling of the corresponding human functions. In this manner the automation of the latter is carried out.

The automation of troop control is a complicated and many-sided process. In its various stages all or many of the above-mentioned varieties of modeling will be employed. Within systems analysis this notion operates as a compulsory demand.

In modern literature it has been noted that the elaboration of complicated systems assumes:

1) The determining of the goals which should be achieved by the given system and which determine the sense of its functioning;

2) The defining of alternatives (variations) by which the proposed goals can be attained;

3) The determining of the criterion by which the alternative variations are compared and one of them is selected;

4) The determining of the resources (means and expenditures) necessary for creating and using one or another variation of the system;

5) The constructing of a model which schematically depicts the given system which links the goals, the alternatives and the resources together.

The designated elements are the initial reference points in systems analysis. From the list of them it can be seen that modeling acts as a necessary and fundamental operation. If the essence of this operation is brought out more widely and in greater detail, it can be seen that actually it consists of a number of operations: the consistent construction of the models with the differing volume of an information content.

In the process of solving the problems of automation, it is essential first of all to construct an initial conceptual model, that is, to elucidate and generalize the existing scientific notions on such systems, and to elaborate a viewpoint on their essence, on the laws of their construction and functioning, and on the possible ways for their elaboration and use.

Then the necessity arises for models of a higher level and for a schematicized information which characterizes the goals and means, the structure and functions of a broader, more complicated system. Such a model makes it possible to correctly determine the place and role in it of the investigated and planned system, and to express its goals and functions more accurately.

The next step is the constructing of middle-level models which would reflect the alternative variations of the very examined system and its basic general characteristics (efficiency, cost, dynamicness, reliability, and so forth). On this level it is important to work out the parametric models which determine the basic indicators of the system and which direct the collection and processing of the necessary factual data.

Finally, the transition to more concrete and detailed research requires the constructing of inferior-level submodels which reproduce the individual subsystems and elements, their structures and functions, their place and role in the designed system.

If one encompasses not only the theoretical but also the empirical level and considers all the stages in the development of automated control systems, then the role and diversity of the employed models becomes even more amazing. In foreign sources, four basic stages have been established in the elaboration of any ASU: Scientific research in a broad and special area, the designing of the system, its constructing, and, finally, production, testing and adjustment of the system. All the known types of models are employed in the stage of wide area scientific research. The main thing here is a precise positing of the problems, an elucidation of the conditions and the ways for solving them. Understandably, this requires first of all a constructing and analysis of conceptual and symbolic models. Here not only the existing scientific information on the modeled object is employed, but also intuitive guesses, analogies and hypotheses. The constructing of such models makes it possible to clarify and systematize the information on the object, to disclose gaps in the knowledge about it and to a certain degree fill them, and at the same time, to recognize the degree of complexity of the problem and the possible ways for solving it.

The elaboration and detailing of these models make it possible to move on to a mathematical logical modeling of individual elements and operations. In the stage of special scientific research, and particularly in the stage of designing a specific system, mathematical logical modeling assumes decisive significance. A strict mathematical description of the individual processes in the form of systems of equations, matrices and schedules makes it possible to clarify and optimize the indicators of both the individual assemblies and processes as well as the device or system as a whole. At the same time, in the designing stage physical modeling is also used in addition to the creation and testing of physically similar, physically analogous and particularly cybernetic models realized on universal computers.

In the stage of constructing automatic devices, physical, technical and particularly cybernetic modeling assumes the basic weight. Here begins the material embodiment of the design. Naturally, some of its ideas which may seem correct on the level of theoretical development may be in conflict with practice and for this reason require checking out and

correction. The modeling on analogue and digital computers makes it possible to clarify many specifications, and to test out intermediate results without waiting for the completion of construction. It is essential to point out one particular feature of a universal computer. The problem is that within its intrinsic structure it is possible to create and test an information model of any other technical device, including another computer. Such a possibility is of exceptional significance since in the process of automation the crucial role is played by the elaboration of different specialized informational, logical and computational devices.

Finally, in the stage of production, testing and adjustment, the technical embodiment of the design in life occurs. The modeling process ends with the creation of a technically working model, an example of the designed device. The testing and adjustment of the example in turn are related to the use of certain varieties of physical modeling. For example, the model can replace an object with which the developed sample directly interacts or a system of which it is a part as a component element, and it may also replace the medium and conditions in which it functions. Such a model or semimodel experiment with a sample can be carried out in the form of stand testing, testing on analogue and digital computers, and, finally, in the form of military games and military exercises through which combat and the real conditions for the functioning of the created devices are modeled.

In solving the problems of optimizing control, the same varieties of models are employed, but in specific forms and in an unique sequence. The constructing of a conceptual model (a model concept) of a combat situation or the course of combat is the start of optimizing a combat decision and its initial condition. In the early stages of the development of military art, the constructing of such conceptual models and their playing out in one's mind was generally the sole means for determining the suitable method of action. However, with the development of military art, the use of such models with intuitive evaluations of possibilities became insufficient. For this reason more complex forms arose for modeling combat as well as special procedures for optimizing decisions.

On the basis of the primary model concept, it is possible to construct a symbolic or graphic model of the existing situation and a plan of actions in it. In the 18th and 19th centuries, such models were constructed in the form of the disposition of the engagement. Later on these were replaced by a working map with the situation and variation of decision, a diagram or schedule with the accompanying descriptions. These made it possible for an experienced commander or staff to make a quantitative and qualitative evaluation of the decision variation and when necessary to correct it. However, an evaluation of a decision variation on the basis of a symbolic or graphic model was incomplete and to a very limited degree permitted the use of mathematics. For this reason, the staffs resorted, on the one hand, to military games, and on the other, to special mathematical logical models making it possible to widely use the mathematical methods of operations research.

Game models are the physical, seminatural reproduction of combat, an operation or any conflict situation generally. These include: troop exercises and maneuvers, headquarters exercises, and military games on maps. Troop exercises and maneuvers are too complex and cumbersome a method for optimizing decisions and planning in the course of combat. In this regard, headquarters exercises and particularly military games on maps possess significantly greater opportunities under the conditions of organizing them on a modern scientific and technical basis.

In literature it is possible to encounter many examples of using military games on maps precisely for the purpose of optimizing decisions and planning combat. Mar SU G. K. Zhukov described a military strategic game conducted for these purposes at the end of 1940, and as a whole highly praised the role of military games in raising the operational-strategic level of the superior command.[3] In the U.S. military literature examples are given of the strategic games held in the autumn of 1941 by Japan for the purpose of working out the plan for the surprise attack on Pearl Harbor. The effectiveness of these games was affirmed by the subsequent course of action.[4]

Along with the game modeling of the course of combat for the purposes of optimizing decisions and planning, ever greater significance is being assumed by the constructing and analysis of mathematical logical models using operations research methods. As was already pointed out, a graphic or symbolic model of a combat situation creates the necessary prerequisites for operational and tactical calculations. However, for a more complete and thorough application of mathematics, different models are needed which schematically depict certain traits of the most characteristic situations which are repeated in different combat. For example, in many instances it is essential to solve the problem of locating and detecting the enemy, the allocating of targets among weapons, the attacking of the enemy in a certain order and sequence, the choice of a method of action considering the enemy's counteractions, and so forth. The commonness and similarity of such situations and tasks make it possible to construct abstract standard models which reproduce entire classes of events, and to work out the mathematical apparatus corresponding to these models. In Soviet and foreign literature, several score such models have been described and the mathematical methods of their analysis given.

Among the mathematical logical models, one must isolate two varieties which are of fundamental difference: analytical and stochastic models. The former are mathematical descriptions of reality (systems of equations, matrices and so forth) which are examined by theoretical analysis and the necessary calculations. The latter are a logical copy of game models. These are logical descriptions of studied situations with their subsequent playing through using the method of statistical testing. Both varieties of models complement one another and are often employed in different combinations.

The improving of seminatural game modeling, on the one hand, and the mathematical logical of the mentioned varieties, on the other, makes it possible to approach a solution to the problem of the complete modeling of combat on electronic computers. The computers open up the way to constructing and examining analytical models of high complexity. With them it is possible to realize statistical models which rather completely reflect reality, and here to play through each of the variations of a decision in as many times as is needed for obtaining reliable statistical estimates. Finally, the computers open up the way to an organic synthesis of analytical and stochastic modeling, to reproducing combat in its dynamics, and this, in turn, makes it possible to prepare the quantitative grounds for taking a decision in a time acceptable under the conditions of modern high-speed combat.

Thus, the basic stages in the development and use of models in the interests of optimizing a decision and automating this process are: The forming of intuitive model concepts on a combat situation and its changes; the constructing and analysis of formalized graphic or symbolic models; the carrying out on their basis of seminatural, game and special mathematical logical models; on the basis of synthesizing these procedures, the elaboration of programs for modeling combat in its dynamics using a computer.

In any modeling it is important to solve the question of the advisable completeness of the model, the level of its complexity, and the degree of its conformity to the original. Two trends can be observed in the solving of such a complicated question. One is in the desire to bring the model as close as possible to reality, to consider in it as many factors as possible which characterize the process. However, this can lead to undesirable results, such as: the main patterns are lost behind the random form of their manifestation; the approximateness or probability nature of the estimates of many factors lead to an ambiguity of the overall result. The other trend is in the maximum simplification of the model, and this facilitates the application of the mathematical apparatus to it and the obtaining of sufficiently definite conclusions. But at times this path leads to negative phenomena such as the accepted assumptions on a certain level begin to distort the very essence of the examined phenomenon or the nature of the patterns operating in it. For this reason the choice of the necessary degree of approximation of the phenomenon and the advisable complexity of a model requires a concrete approach, special methodological analysis and certain experience in solving such problems.

The development of modern forms of modeling and the ever fuller use of mathematical methods for describing the crucial aspects and characteristics of examined phenomena is impossible without their formalization. In essence, such a necessary stage of any modeling has the constructing of conceptual, symbolic or graphic models of an object already represents the process and result of formalization. In this regard there must be more profound analysis of the method of formalization generally, and

particular attention paid to the potential and real possibilities of formalizing the processes of armed combat and the controlling activities of commanders.

2. The Necessity and Possibility of Mathematical Logical Formalization of the Troop Control Process

The optimization and full automation of a control process make it possible to bring the troop control system into accord with the increased demands upon the speed and accuracy of its functioning. At present a fundamental rise in the productivity of the command labor of a commander and staff officers is being carried out precisely on a basis of the extensive use of modern technical devices and mathematical methods. However neither the optimization nor the automation of control processes is possible outside their mathematical logical formalization. The opportunities of optimization and automation are determined by the broad use of mathematical logical methods and by the degree of formalization in the corresponding areas. The questions of the mathematical logical formalization and the use of mathematical logical methods for describing the processes of armed combat and troop control have been widely taken up in our military theoretical literature.[5]

What has caused such a broad penetration of mathematical logical methods into the sphere of troop control? What is the tie between automating the control process and its mathematical logical formalization?

Under present-day conditions, one of the most essential features of troop control is the circulation of an enormous flow of information in the system, and this flow is constantly rising because of the increase in the scope of the operations conducted, the rise in the pace of armed combat and the use of weapons of mass destruction. At the same time, under the conditions of the extreme high speed of combat, the process of the rapid aging of information occurs. Hence the need arises of a rational organization for the flows of information, for reducing the time spent on its collection, receiving, transmission, display and processing, an increase in the accuracy of processing, the excluding of possible errors as a consequence of random or organized interference, and so forth.

These demands can be formulated more precisely as problems of synthesizing the systems of information processing, coding and decoding, the providing of the greatest throughput capacity of the communications channels, the finding of an optimum number of these channels for each specific control system, and finally, providing the necessary resistance to jamming in the system. The correct solution to the designated problems is possible only on the basis of the extensive use of quantitative methods which have been worked within information theory and are expressed in a whole series of mathematical concepts and strictly proven theorems. Their practical use understands a simultaneous formalization of the descriptive relations of the corresponding area, or more accurately the very process

of applying these methods expresses one of the possible forms of mathematical logical formalization.

However, the use of mathematical methods for the purpose of finding the optimum values for parameters of data collection, processing and transmission systems is far from limited to the area of their use in the troop control process. The central operation of control generally and the basis of troop control, in particular, is the taking of a decision. While an optimum choice, the prompt transmission and efficient recoding of information play an important role in increasing the accuracy and reducing the time of the complete control cycle, of even greater significance is the use of this information for the purpose of optimizing the very decision to be taken by the commander. It is always desirable that the commander's decision be an optimum one in relation to the specific conditions and requirements of the combat situation.

In what manner can one be convinced that a decision taken is an optimum one? Certainly in the same situation different decisions could be formulated and the person who has made them is confident that precisely his variation is the optimum one. Moreover, each person points to definite reasons for the choice made and gives the corresponding line of argument on its behalf.

Certainly, under the conditions of the sharp complicating of the troop control process, the greater responsibility for the decision taken and the shortening of time for making it, such traditional bases as collective and personal experience, intuition, and logical arguments, while being essential as before, are no longer sufficient. In this situation, along with a qualitative evaluation of the possible plans of action, quantitative estimates also assume decisive significance. Although attempts at obtaining quantitative estimates for basing a decision occurred in the past, however the truly broad and sufficiently effective use of mathematical logical methods for this purpose have been related to the present-day revolution in military affairs. This has been brought about by the development of military science as a whole, by the high level of elaboration for the corresponding formal apparatus, and by the objective demands of troop control practice. At present one clearly feels the very close tie between control, optimization and automation, on the one hand, and mathematical logical formalization, on the other. In a certain sense the aim of control consists in optimizing the process. At the same time, optimization can be carried out only by a quantitative comparison of different control variations, and this, in turn, requires the most complete formalization possible. Certainly for solving the problem by quantitative methods, its conditions must be expressed in the language of mathematics, that is, formalized.

Thus, the problems of optimizing the data processing and decision taking processes determine the broad use of formal mathematical logical methods.

Mathematical logical formalization is closely tied not only to optimization, but also the automation of control.

Understandably, definite difficulties of a theoretical, technical and practical nature arise on the path of automating the individual elements of troop control and particularly full automation. However, with other conditions being equal, it is possible to automate only those control operations which at the given moment permit formalization and can be described by logical and mathematical means. The functioning of any automated control system requires a definite mathematical logical description, algorithm and program, that is, a system of formal rules the fulfillment of which makes it possible to solve the problem without elucidating its content. For this reason, the possibilities of automating the troop control process at each specific stage are determined ultimately by the successes in the formalization of one or another of its component parts. It can be said that the degree and depth of automating control are directly determined by the development level of the mathematical description of the processes of armed combat. At the same time, the tendency toward formalization has been substantially strengthened precisely because of the development of automation which creates the prerequisites for the extensive use of mathematical methods for solving control problems, it presupposes their development and is based on them.

All of this points to the necessity of introducing mathematical logical methods into the theory and practice of the troop control process for the purpose of its optimization and automation. As for the possibility of such an introduction, its realization requires the presence of a number of conditions.

Widely known are the remarkable words of K. Marx that science will reach perfection when it succeeds in using mathematics. At the same time, science can use mathematics only when it reaches a certain perfection, when it penetrates deeply into its own subject, when it isolates and fixes the fundamental relationships and ties of the studied phenomena, and creates a sufficiently clear and developed conceptual apparatus.

In linking the possibility of the mathematization with the approximation of the corresponding science to simple, uniform elements of matter, V. I. Lenin, for example, pointed out: "The unity of nature is disclosed in the 'striking analogy' of differential equations..." and further: "'the uniformity of matter' is not a postulate but rather the result of the experience and development of science and the 'uniformity of the object of physics' this is the condition for the applicability of measurements and mathematical calculations."[6]

Accuracy and the greatest possible uniformity of definitions, the aggregate of which makes it possible with sufficient fullness to express the content of concepts and terms, are indispensable conditions for mathematical processing.

"Naturally," writes the German Marxist philosopher G. Klaus on this question, "mathematics can be applied in a certain area of science only in the instance that the posings of the problems and the systems of concepts in this area of science have been formulated so clearly as to allow mathematical processing. A representative of a specific science or a philosopher who has still a very hazy notion of one or another subject and who clearly does not know what he, in essence, wants to say should not hope that this still undigested product of his thinking could be treated by the precise instrument of mathematics. And of course, he should not criticize mathematics for the fact that in the given instance it cannot help him."[7]

Consequently, the use of mathematical logical methods in studying the sphere of troop control is possible in the instance when this sphere itself has been sufficiently well studied and defined in the concepts and terms of the military science studying it.

Soviet military science ever more profoundly and completely is examining the patterns of the processes of armed combat generally and troop control, in particular. At present a number of laws of military science and principles of military art have been formulated. Essential ties have been disclosed between the course and outcome of a war and the economic, political, moral and other factors. Attempts have been made to consider chance in war. The basic provisions have been worked out for the theory for troop control. A profound informative analysis, strictness and accuracy in operational-tactical descriptions, and the development of the corresponding conceptual apparatus within the theory of control and military cybernetics make it possible to build that informational foundation which is the basis for the use of mathematical logical methods.

Another important condition which determines the possibility of a mathematical description of the processes of armed combat and troop control is the presence of a corresponding formal apparatus which is capable of depicting the studied descriptive ties in an adequate mathematical form.

The rapid development and definite advances in social sciences generally and the various areas of military science and the theory of troop control in particular have placed new demands on the mathematical disciplines, and have demanded the improvement of the old formal apparatus and the creation of a new one capable of most fully reflecting the content and specifics of the corresponding areas in a mathematical logical form.

However, regardless of certain advances in the area of mathematization, even now there are frequent arguments against the broad and systematic use of mathematical logical methods in the sciences which study the higher forms of the movement of matter. Doubts are voiced particularly often on the possibility of a mathematical logical formalization of processes occurring in the social sphere (this includes the area of troop control).

Here it is ordinarily pointed out that the essence of mathematical logical formalization consists in an abstraction from the content and qualitative specifics of the studied subjects and phenomena. Supposedly only quantitative relationships and spatial forms of subjects, phenomena and processes can be studied in an abstract mathematical logical form, while their essence remains undisclosed. In this regard, one must particularly point out the fact that the fundamental gnoseological possibilities of mathematical logical formalization are determined by such underlying postulates of dialectical materialism as the thesis of the unity of the world, the unity of quantity and quality, form and content, phenomenon and essence, and abstract and concrete.

The broadening of the possibilities of a mathematical logical description, and consequently, the automating of the troop control process, as was already pointed out, is most closely tied to the extending of the boundaries of mathematics itself and mathematical logic, and above all, to a change in the very subject of mathematics.

Fundamental for an understanding of the essence of mathematics is the classical of its subject given at one time by F. Engels. "Pure mathematics," wrote Engels, "has as its object the spatial forms and quantitative relationships of the real world...."[8]

However, the rapid development of mathematics over the last century makes it possible at present to say that its subject is not only the spatial forms and quantitative relationships, but also similar relationships, forms and structures taken in abstraction from their content. An analysis of the process of the enrichment of the content and the ever greater separation of the very concept of quantity and quantitative relationship in mathematics leads one to this conclusion. Modern mathematics is moving from relationships characteristic for numbers and amounts to any abstract relations between any conditional objects, to an abstract relation generally.[9]

In other words, any relations abstracted from content are related to the area of quantity and quantitative relationships. The laws of the interconnection of relationships like the forms abstracted from content are characterized sufficiently adequately by abstract structures. Thus, we approach an understanding of modern mathematics as a science dealing with abstract structures and the laws of their functioning. From this directly follows the conclusion that the structures of the weapons and troop control systems and the laws of their functioning on a certain level of abstraction can be described sufficiently fully using one or another mathematical logical apparatus.

Let us now turn to the characteristics of quality. In the most general sense, quality is the internal definiteness of a thing identical to its being. At the sources of theoretical cognition, quality acts as the primary, simplest and rather content-poor logical expression of sensory experience. "Sensation is the foremost and most initial, and quality is inevitable in it...," noted V. I. Lenin.[10]

The attempt to concretize the concept of quality, that is, to move from quality generally to studying quality or qualities of a given thing for specific phenomenon presupposes an elucidation of a number of questions: What makes it possible for us to identify or distinguish these phenomena, what lies at the basis of their specifics, integrity or stability, and what makes it possible for a thing to act in a given quality?

While at the initial stages of cognition quality acts in the form of an aggregate of sensorily perceived data, in then growing into an ordered system of essential properties, a further deepening of cognition leads to an understanding of quality as the integrated characteristics of a ting, phenomenon or process. But such characteristics can be given only with a sufficiently complete description of the internal order and external relationships of objects and phenomena. In others words, the qualitative definiteness of a given object is most completely disclosed in the characteristics of its organization, structure, internal and external relationships and ties.

The category of quality precisely reflects the difference and similarity of corresponding structures. Consequently, a sufficiently complete and integral description of quality is impossible without using formal, quantitative methods, and without using the language of mathematics and mathematical logic as a science dealing with abstract structures. In this instance the mathematical logical methods not only make it possible for us to investigate the various structures of troop control systems, but also provide an opportunity to a definite degree of judging the quality of control, to evaluate this quality and improve it.

Thus, any qualitative certainties with known conditions, with a certain degree of accuracy can be expressed in a mathematical form. At the basis of this possibility lies an objectively existing inseparable unity of quantity and quality.

Mathematics and mathematical logic are the providers of the most diverse mathematical logical abstract structures for the various areas of natural and social sciences and theories, including for a number of areas of military science and troop control theory. However, for the sciences and theories which use formal methods, it is very important precisely what mathematical logical structures must be employed in each specific instance. Here one can no longer speak of any abstraction from quality. On the contrary, the commonness or specificness of quantitative relationships is determined precisely by the commonness or specificness of the qualitative certainties or certain properties of the examined processes and phenomena. In other words, the isomorphicness of quantitative relationships is to some degree the result of the similarity of qualitative certainties. For example, the following fact is an unique reflection of the unity of quantity and quality: the mathematical apparatus which serves one area of knowledge well is in no way necessarily acceptable in another sphere. Previously mention was made of the necessity of working out and

developing a mathematical logical apparatus which would adequately reflect the specific patterns characteristic for the area of armed combat and troop control.

An analogous conclusion is inevitable in analyzing the given problem in a somewhat different aspect, and namely on a level of the unity of form and content. Being an aggregate of elements, objects and processes, content expresses itself in a certain specific form: an organization, system or structure.

However, the broadening of the sphere of use of artificial languages has entailed a definite separation of the formal aspect of knowledge from its content aspect. As is known, the same mathematical logical structure can be a form for expressing a different content. It can be used for the adequate description of phenomena belonging to different areas of knowledge, and on the contrary, the same phenomena can be reflected by different abstract structures. Nevertheless, the abstraction from content is never absolute. In emphasizing this fact, Academician A. Aleksandrov has written: "An indifference of pure forms to content merely means that they are encountered with a completely different content (in the same manner that the same formula can express the laws of phenomena which differ in their nature). But this in no way means that these forms always have an external or purely quantitative nature."[11]

The presence of content ultimately is manifested within any formalism. Any logical form is based on content and, in being constructed, returns to the area of content relationships. An abstracting from content occurs only in the process of constructing mathematical and mathematical logical systems.

When necessary it is possible to operate with signs or symbols, without thinking of their sense, and considering only the preset rules for using them, that is, formally. But when the necessity arises of interpreting a system of signs, it turns out that the relationships between them are a reflection of the ties between the content of the concepts, they operate as a mathematical logical form for the expression of these ties, and consequently, assume the sense of content.

The place which the aggregate of signs occupy in one or another system, their relationships and ties reflect the content ties and relationsips of objects and phenomena, or more accurately their mental and sensory images. Thus, a study of symbol forms encompasses a definite area of content and specific aspects of content relationships. Since the particular feature of formalization consists in elucidating and clarifying content by the elucidation and fixation of form, to this degree the thesis on the unity of form and content is a theoretical base for mathematical logical formalization. Thus, mathematical logical methods make it possible not only to examine quantitative relationships and forms of phenomena, but also to a definite degree to express their content and qualitative specifics.

The cognition of quantitatively determined quality and the content forms of phenomena belonging to a certain actual area using mathematical logical methods provides an opportunity to isolate and study the essential links, relationships and patterns inherent to a given area. The mathematical logical form for expressing laws represents a necessary stage in the cognition of essence.

Consequently, the indications of the narrowness of the sphere of using the methods of mathematical logical formalization are unconvincing. On the contrary, precisely the above-named general fundamental theses of dialectical materialism are the theoretical basis for very broad opportunities of using these methods as well as for their future development.

In relying on this, it can be asserted that at a certain stage in the development of cognition, a number of areas of military science will be so thoroughly and soundly formalized as, for example, certain military technical disciplines presently are. In these areas and in military science as a whole new directions and scientific theories will arise and at the given stage they as yet will not be sufficiently widely used by mathematical logical methods.

What has been said applies fully to the mathematical apparatus used for the optimization and automation of the troop control process. At present the corresponding apparatus is being intensely developed in such areas of mathematical disciplines as information theory, the theory of algorithms, game theory, queueing theory, linear and dynamic programming, and the theory of statistical decisions which are widely used within a single scientific direction, operations research theory.

The use of the ideas in operations research theory for the purpose of optimizing and automating the troop control process through a strict quantitative establishing of the taken decisions was a qualitatively new stage in the application of mathematical methods in military affairs.

The theory of operations research acts as a concrete expression of the method of mathematical logical formalization for a specific sphere of cognition of purposeful and organizable processes, including primarily the process of troop control. It is concerned not so much with the elaboration of the mathematical methods for describing and optimizing the decision taking process, for these methods are developed basically within the corresponding mathematical disciplines as it is with the question of using these methods in a specific situation.

It is important to point out that within the application of operations research theory and decision taking theory which derives from it, in military affairs the entire complex of mathematical methods is developed considering the specific features of the processes of armed combat and troop control.

The mass random phenomena of armed combat can be investigated and described using the mathematical apparatus of probability theory and mathematical statistics. For example, probability theory is widely used in evaluating the effectiveness of new types of weapons and weapon control systems, in solving the problems of controlling tactical units, and so forth.

The specifics of troop control in combat is most clearly manifested in the fact that the decision must be taken in situations when the enemy endeavors to disrupt our control system or to cause maximum damage to it. In such instances it is desirable to find and realize a model of actions which would lead to the most favorable outcome for us. Here it is essential to consider the fact that the enemy will seek out the least favorable method of action for us. The described conflict situations can be evaluated quantitatively with the mathematical apparatus of game theory, and this makes it possible to find the advisable methods of controlling one's forces and means on a basis of detailed consideration of the possible variations for the enemy response actions.

Along with game theory, for solving a whole series of specific control problems related to assessing the quality of the created systems and modeling combat, the rather fully elaborated mathematical apparatus of queueing theory can be successfully applied.

The linear programming method is used for taking a decision under conditions where the situation is known and the efficiency criterion represents a linear function of independent variables. This apparatus is most widely used in solving the problems of allocating targets, objectives, as well as one's own forces and means.

However the specific features of troop control require, as a rule, a detailed consideration of the continuously received additional data on the changing situation. In such instances control is optimized each time only for an immediate time interval, but in such a manner that at the concluding stage the greatest effect of obtained. Such problems are solved by the dynamic programming method.

When a decision is taken under the conditions of a definite ambiguity and the random nature of the situation must be considered, statistical methods are used.

At present the mathematical apparatus of information theory, the applied theory of algorithms, algorithmic and informational languages and so forth are assuming a particularly important role for formalizing the control process generally and troop control, in particular.

Thus, the complexity of the ties and relationships disclosed and studied by military science and the necessity of optimizing and autcmating troo control processes have necessitated the use of mathematical logical methods. At the same time, the depth of penetration of military science (and in

particular, troop control theory) into its own subject creates a real opportunity for such use, and the mathematical logical apparatus which is being intensely developed even now makes it possible to turn this to a certain degree into a reality.

Since the question of the possibilities, ways of development, basic directions and sequence in realizing automation and optimization can be solved only in its relation to formalization, to this degree the disclosure of the essence and content of the very method of mathematical logical formalization assumes particularly important significance. The corresponding general methodological analysis will make it possible to correctly define the role and place of the method of mathemaitcal logical formalization in the process of optimizing and automating troop control.

3. Mathematical Logical Formalization as a Stage in the Optimizing and Automating of Troop Control

The method of formalization was recognized as independent and gained its most complete development within mathematics and mathematical logic. The formation and development of this method was also greatly developed by traditional formologic, and in our times, by theoretical cybernetics. The definite traits which are already characteristic for traditional formologic of a formal approach to investigating the forms of thought, in being developed and assuming an ever more apparent nature, grew up in relation to the rise and development of mathematical logic into an unique, specific and at first special method of research, the method of formalization. The further development of this method led to a situation where a rather complete and consistent formalization of entire areas of knowledge or sections of sciences became possible by constructing completely or partially formalized symbolic systems which operate with signs and symbols according to previously determined rules.

In a most general form, formalization is a precise description of a studied phenomenon, process or object in a certain fixed or specified (or even natural) language. In emphasizing this significance of the term "formalization," V. M. Glushkov has written: "The task of scientific cognition consists precisely in converting informal things into formal ones, that is, to put it simply, into precisely described ones."[12]

The level of formalization, depending upon the employed mathematical logical means and its end result, can vary. While the rise of language, the imparting of a name to an object, the appearance of writing and the rise of counting are the initial stage of formalization, the mathematization and algorithmization of various areas of knowledge can be considered the following, higher level. The constructing of symbolic systems in a calculation must be put among the third, most developed level of formalization.

Thus, in accord with the varying completeness of the formal transformations of studied phenomena, it is possible to speak of three relatively independent levels of formalization. Acting as the delimiters of these levels are the description of the studied phenomena by the means of the fixed or specified natural language, the mathematization and algorithmization of the studied areas and processes, and, finally, the constructing of symbolic systems and calculations.[13]

The particular, concrete mathematical logical methods act as specific forms for the manifestation of the unified method of formalization. In such an understanding, formalization represents a general scientific method of cognition standing in the same line with such methods as analysis and synthesis, abstraction and the ascent from the abstract to the concrete and which are used with equal success in all areas of human activity and on any levels of cognition.

In the given instance of particular interest is the mathematization and algorithmization by which the partially formalized theories oriented at use in various natural, technical and social sciences are created. On precisely this level, mathematical logical formalization penetrates broadly into military theory and practice, and is used for describing troop control processes for the purpose of their optimization and automation.

Mathematics operates with numbers, vectors, operators and other mathematical objects which are the result of abstraction and idealization. The attempt to bring such a purely mathematical theory or its elements into accord with certain relationships and objects of the real world or another theoretical system can be classified as a partial formalization of the studied area. The partially formalized theory obtained in this manner is no longer purely mathematical. It represents a portion of theoretical natural science. Characteristic for the designated level of formalization is the use of a mathematical apparatus in accord with and in close relation to the definitions, concepts and assumptions of the given descriptive scientific theory. Consequently in the area of the optimization and automation of troop control, it should be a question of the relationship of the mathematical apparatus to the concepts and propositions of tactics, operational art, the theory of troop control, and so forth.

Since the mathematical apparatus can be applied only to well defined abstract objects, in automating the various elements of the troop control process it is essential to isolate these abstract objects within the examined area. Then they must be represented in the form of a certain integrated system, and the underlying time, space, causal and other ties and relationships inherent to them must be detected and fixed, that is, the general abstract structure of the studied area of control or the descriptive theory reflecting it must be determined. The isolating of such elements and structures is the first step in the formalization process.

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For obtaining practically signficant results, certain variables, functionals, operators and other objects of the selected mathematical language are brought into direct accord with the previously isolated abstract objects. The established ties and relationships between the elements, in characterizing the structure of the given system, are expressed in the form of functional and probability dependences, logical rules, schedules, tables, and so forth. A system is formed of certain parameters which subsequently figure as the initial, basic premises (factors) of the investigated (designed) control theory or specific problem being solved. The aggregate of the described operations can be considered the second step of formalization.

The next step in the process of formalization consists in the following: the previously isolated elements and structures of the investigated processes and phenomena or the system of parameters reflecting them are brought into adequate accord to certain mathematical structures relating to definite areas of mathematics.

Thus, any formal (axiomatic, analytical, algorithmic, and so forth) description can act as a definite means for formalizing the phenomena of armed combat and the troop control processes, and serves as the starting point of their further optimization and automation.

The role and place of mathematical logical formalization becomes understandable in the process of optimizing and automating troop control.

In actuality, in solving any problems of optimizing and algorithmizing troop control, the following stages can be isolated: The posing of the mission, the selecting of the efficiency criteria, the determining of the parameters of the operation and their relationships, the designing and investigation of the formalized mathematical model of the operation, the interpretation and testing of the theoretical conclusions in practice. In each of these stages, with the exception of the last one, along with a descriptive analysis, extensive use is made of the formalization method which ultimately provides an opportunity of solving the problem by mathematical means.

Even in the process of posing the problem, a clear and sufficiently accurate exposition of the initial data, the conditions of fulfillment and the required results of the decision makes it possible to disclose its abstract, logical structure. This disclosure provides an opportunity to use one of the previously examined mathematical models for solving a broad range of uniform specific problems. Let us illustrate this from the examples of a number of specific particular problems solved by the means of operations research theory.

1. For example, a certain group of specialists is servicing the combat of an air fighter regiment. Its task includes the inspection and repairing of the aircraft arriving at the airfield in order in the shortest time

to ready them for the next sortie. The insufficient size of the group or lacking number of specialists in the individual services can lead to an inacceptable delay of the aircraft in the parking area; an irrational increase in this number leads to the irrational use of the personnel. The question arises of an optimum composition and size of such a group.

2. A certain sector of an air defense system as a fixed number of forces and means (antiaircraft missile units, interceptors, and so forth) for repelling a bomber raid. It is essential to disclose how the defense system can be organized so that the greatest number of bombers in the raid would fall under the action of the air defense forces.

3. Information from the site of combat is received at a command post via the communications system. The time for the traveling of individual messages depends upon the number of communications channels. Considering that the promptness of decision taking by the commander depends upon the time required for the messages to pass through the communications channel, to determine the number of channels which ensure the given speed.

The use of mathematical methods requires, as we have seen, the isolating of certain common traits which characterize the abstract structure of those processes to an analysis of which they are attempting to be applied, particularly when it is a question of an attempt to solve a group of problems by one mathematical method.

In all three problems one can note a certain common element which can be termed a serving system. In the first instance this is a group of specialists, in the second the air defense weapons, and in the third the communications channels. In isolating this element, we disregard the concrete forms of service, the characteristics of the very servicing equipment and in whose interest the servicing is carried out.

Another element which is inevitably present in all the given problems is the flow of demands or the flow of clients coming in to the input of the servicing system. In the first instance the aircraft arriving for servicing must be considered the client, and in the second the bombers which break through the air defense system, and in the third, the messages passed through the communications channels. Here also it is of no importance from whom the demands originate or who is interested in their satisfaction. The term "client" or "demand" generalize all the possible types of requests for service received from any object even the most different in their nature.

Finally, it is not difficult to notice the similarity in the very logical structure of the processes described in the given problems. This similarity consists in the fact that in all the instances the input of the servicing system receives a flow of demands or clients which either are satisfied immediately or form a line or leave the system. The similarity of structures makes it possible to solve such a problem by uniform mathematical methods which are grouped together under the common name of

queueing theory. Clearly the number of problems similar to the ones examined is virtually unlimited, while the sphere of application of the general methods for solving them is extremely broad.

Let us examine one other example. It is essential to organize an air defense system for a certain installation. Here it is assumed that the enemy possesses a whole series of possibilities for organizing an air raid on the defended installation. In precisely the same way the defending side has types of defensive weapons which differ in terms of their tactical and technical specifications. It is essential to resolve the question of the best combination of these types of weapons under any enemy actions.

The following situation is present. There are two sides, "players," which pursue the opposite interests. The winning of one side or "payment" is at the same time the losing of the other. Both sides have the possibility to a certain degree of influencing the course of events, in choosing one or another way of action, a strategy. For example, the attacking side can use various types of aircraft, and vary the type of formation and the method of approaching the target. The defending side uses various air defense weapons and creates different groupings of them. Finally, there is a number of factors which do not depend upon the procedure of the sides. In the designated instances, for example, the meteorological conditions can be put among these. Each side considers the reasonability of enemy actions and endeavors to choose that strategy which would ensure the maximum possible average winnings under any of the most unfavorable actions of the opponent.

Understandably in actual reality, and particularly in armed combat, it would be possible to discover an enormous number of situations the structure of which was generally similar to the one described above. Moreover, it can be said that the troop control process, both in its various parts as well as on the whole, consists precisely of such situations. Since the logical structure of all such problems is generally similar, to this degree they are solvable within one mathematical method, game theory.

The situation is precisely the same in the event of using such mathematical methods as linear programming, dynamic programming, statistical decisions theory, and so forth. For example in order to use the linear programming method, it is essential to reduce the examined real situation to a form permitting its description as an aggregate of linear equalities and inequalities.

Thus, precisely the dismembering of similar abstract structures makes it possible to employ uniform mathematical methods for solving an entire series of seemingly very distant specific problems, and this is the theoretical foundation for optimizing and automating their solution.

The next major stage upon which essentially depends the entire further course and end result of the optimization and automation of any control process is the selecting of the efficiency criterion. The question of finding an optimum solution makes sense only in the instance that an optimality criterion is established.

The choice of an optimum solution implies the necessity of a comparison between several variations using a principle which is determined in turn by the aims and tasks of each specific operation. For example, the success of offensive operations by troop group in a certain sector of a theater of operations can be judged from the rate of advance and the amount of losses of the enemy and our troops. The mathematical apparatus makes it possible to find an optimum solution for any of these indicators, however the choice of the criterion is made on the basis of a descriptive analysis of the specific conditions for carrying out the operation in accord with its aims.

For example, during World War II, the Allies were confronted with the question of the advisability of arming submarines with homing torpedoes. The maneuvering of enemy subs sharply reduced the probability of a torpedo hit. However, this also impeded the operations of the subchasers. When the percentage of subchaser losses was used as the efficiency criterion, it turned out that the use of torpedoes was ill advised. But when the ratio of sub losses before and after the arming of them with homing torpedoes was used as such a criterion, it turned out that the use of the new weapons reduced sub losses by 3-fold. An analogous situation was created in solving the question of the required number of transports in a convoy. If the absolute losses of transports were used as the efficiency criterion, then it might be concluded that the number of transports in a convoy was of no significance. However, if one considers the ratio of transport losses to the total number of escorted vessels, then the essential advantages of large convoys immediately become apparent.

Thus, the optimum solution is directly dependent upon the aims of the operations. For this reason for solving the problems of the optimization and automation of various elements in the control process, it is essential to incorporate these goals in the conditions of the problems. For this they should be represented in a formalized form. The efficiency criterion precisely represents a formalized expression of the goals of an operation, and in the broader sense, a formalized expression of a practical need. Consequently, without a formalized expression of the efficiency criterion it is impossible to solve the problem of the optimization and automation of control.

An equally important stage in the constructing of a formalized system is the formalization of the factors which influence the occurrence of the studied process and the incorporation of them in the form of quantitatively determined parameters into the condition of the problem. It is essential to disclose the space-time, cause-and-effect and other relationships between the parameters and to fix them in the form of definite rules,

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mathematical formulas, functional dependences of schedules, tables, and so forth. Since the number of factors and their ratios can be extremely great, it is essential to select the most important of them which substantially influence the result of the solution. Here we disregard a whole series of less essential, secondary factors. Such a description differs advantageously from actual reality in its viewability and in the clear fixing of the individual elements and their relationships.

Finally, it is essential to define the general rules on the basis of which the parameters and particular constraints of such a transformation can formally be transformed in the future for each specific problem or for a limited number of control problems. The general rules are determined by establishing the isomorphism (homomorphism or model relationship) of the previously isolated structures with certain mathematical structures. For example, in game theory the general rules of the game can be considered the system of conditions which includes possible variations for the actions of the sides, the amount of information of each side on the behavior of the enemy, the sequence of moves, the result or outcome of the game to which the given aggregate of moves leads. The particular assumptions are determined for each specific problem considering its conditions and the possibilities of the employed mathematical apparatus.

The examined constraints, as a rule, distort the real conditions of the problem. With the accepting of them we remove ourselves from the examined subject area and move from the study of the original to an examination of an integral model.

Consequently, the process of formalization begins by isolating the similar, uniform and abstract structures of different phenomena and ends by the constructing and investigating of formalized mathematical models. It is a necessary and very essential aspect which determines the possibility of optimizing and automating the troop control process. Here mathematical logical formalization acts as the theoretical basis and essential stage of automation.

While the analysis of the basic stages in solving the problems of the optimization and algorithmization of the troop control process indicates the possibility and necessity of a mathematical logical formalization, the question of the degree of formalization in each specific control problem is determined by practice. The use of formal methods for the purpose of a quantitative basing, optimization and algorithmization of a decision being made by a commander is preceded by a profound descriptive analysis of the studied situation which is based completely on practice. Only on this basis is it possible to carry out a correct posing of the problem, its operational-tactical description, and the dividing of factors into essential and nonessential, as well as to determine the necessary accuracy of the decision.

All of this serves as the informational foundation for constructing the corresponding mathematical logical formalized system, and determines the ways for optimizing and the mathematical means for automating the solving of various control problems.

An essential condition of formalization is, for example, the dividing of factors into essential and nonessential. The same factor can be essential for some cases and nonessential for others. There are no essential parameters generally or independently of a specific problem. Thus the question of whether the object of an attack is a point or an area and what its dimensions are is extremely important in evaluating the possiblities of a strike by conventional weapons. However, in the event of using nuclear weapons this parameter is secondary. Thus, precisely practical need determines what factors should be subjected to formalization in each specific problem. And practice also solves the question of the number of these factors. Consideration of a large number of factors causes a more adequate reflection of the basic, essential properties of the studied process in a mathematical logical form. Obviously in this instance one might expect the obtaining of more accurate results. However, in practice frequently such accuracy is simply not needed, and the attempt to consider a larger number of parameters merely leads to a purposeless complicating of the problem and the used mathematical apparatus. For example, while for tactical troop control elements it is essential to consider the location of the enemy targets with very great accuracy, for the operational and strategic elements such accuracy is superfluous. Consequently, the level of the decision, like the number of formalizable factors, is determined by practical need.

The success of solving various control problems, like the automating of this solution, to an essential degree depends upon how completely practical needs will be reflected in one or another formalized criterion. An improvement in the formal methods makes it possible to consider these requirements with ever greater completeness. At the same time, it is perfectly obvious that the entire dialectical process of the development of practical needs cannot in any satisfactory manner be expressed in a single formalism. Moreover, even within a single problem, practical needs cannot be completely considered by any formalized criteria. The latter always are of a relative nature. The given circumstance forces one to seek out solutions which are acceptable for a whole series of criteria, considering the more common aims of conducting the operation. The existing mathematical methods do not provide an opportunity for fully considering these aims and for choosing the corresponding compromise solution which remains the privilege of the commander. Thus, formalization is based upon descriptive analysis, on experimentation and practice, and also has descriptive analysis as its final point, and through it practice. Control practices not only solve the question of the impossibility of complete and absolute formalization of control problems, but also determine the level and degree of necessary and possible formalization for each specific problem. It must always be remembered that formalization

is merely a portion of the work in establishing a decision, and one of the aspects of this basing, and does not claim independent significance for exhaustive analysis of the control process.

In light of what has been said, it is essential to examine the problem of the ratio and correct combination of the unformalized and formalized knowledge in military science and control theory, as well as the question of the ways and specific conditions for realizing the possibilities of mathematical logical methods in the theory and practice of troop control, and in particular, in solving optimization and automation problems.

The analysis made indicates that precisely proceeding from general methodological considerations one must not restrict the fundamental possibilities of mathematical logical formalization. The real opportunities for each historical stage are always limited by the general level of knowledge and by the development of military science, troop control theory and mathematical logical disciplines.

At the given, specific and fixed level in the development of military science and the mathematical logical disciplines, the determined constraints create a complexity and specificness of the very subject of research, the troop control process. For this reason in characterizing the real possibilities of mathematical logical methods in the sphere of the optimization and automation of control, it is important to point out that the problem of formalizing a whole series of qualitatively different specific factors which substantially influence the occurrence of the studied processes, the course and outcome of armed combat, and the effectiveness of troop control as yet has not been completely solved. This problem is particularly urgent in the sphere of troop control. Here there is a large group of factors the quantitative expression of which as yet encounters serious difficulties. For example, morale, discipline, the training level of the personnel, the talents of the commanders, the quality of leadership and the organization of control, and so forth. Their mere listing indicates the enormous significance of these factors for any sphere of combat. In a whole series of instances, they are determining and ultimately settle the course and outcome of an operation. For this reason the commanders of all levels carry out a compulsory qualitative consideration and evaluation of them. Certainly their quantitative analysis would significantly broaden the sphere of application of the method of mathematical logical formalization, and would make it possible to more fully reflect in the formalized models not only the general but also the specific traits of the troop control process. This in turn would raise the level and possibilities of automation.

The reality of armed combat is such that the listed factors are uniquely woven into a fabric of a whole series of other ones, they are inseparably linked and interact closely with them. For example, the solution to the problem of the effectiveness of the specific type of weapons cannot be complete without a knowledge of the degree of training of the personnel

operating this equipment. On the one hand, the given circumstance again emphasizes the importance of these factors, and on the other, indicates the specific ways for considering them, in disclosing the possibilities of an indirect expression of qualitative factors through their quantitative manifestations. Certainly inequality is manifested in properties which in a definite manner influence the occurrence of the process as a whole, and, consequently, can be measured.

In the above-given example, the training of the personnel is manifested in a reduction in aiming errors. This, in turn, influences the evaluation of weapons efficiency. An analysis of the influence of the training time on reducing aiming errors can underlie the determination of the corresponding quantitative functional dependence. The political and moral state of the troops is manifested in the ability to maintain battleworthiness with significant losses or to resist a numerically superior enemy. Consequently, having established the corresponding standards for units of measurement, it is possible to attempt to express this property quantitatively.

Certainly the given examples are extremely oversimplified. In practice the ways of quantitative evaluation for a whole series of factors as yet are still unclear. Nevertheless, since such accounting is fundamentally possible, in the future the number of qualitative factors which are assessed quantitatively and considered in a mathematical logical description will rise. The search for the ways and means for obtaining such evaluations is presently one of the most important tasks in the area of control theory, automation and optimization of decisions being taken.

A majority of the designated factors concerns the social sphere of human activity. For this reason one of the most effective ways in this area, in our view, is the extensive carrying out of various sorts of specific sociological research. This research makes it possible to more profoundly understand the general, specific and particular patterns in the sphere of troop control, to disclose previously unknown relationships, to carry out a quantitative analysis of a whole series of qualitative factors, that is, to describe them mathematically. The mathematical processing of the materials from the applied sociological research makes it possible to interpret these data not only qualitatively but also quantitatively, to profoundly analyze them, and to correctly understand and generalize them. For example, correlation analysis makes it possible to ascertain whether or not all the basic factors influencing the occurrence of the process have been correctly considered.

One of the examples of how a formal approach makes it possible to penetrate more deeply into the content of the studied process is factor analysis. The essential parameters which are to be subjected to a quantitative evaluation are linked in such a manner that within each group the connection between them is closer (a higher reciprocal correlation coefficient) than between the parameters of the different groups. This provides an

opportunity to unify all the parameters of the group into a single factor and determine its amount. As a result the quantity of considered factors is sharply reduced and the studied model becomes more encompassable. Moreover, factor analysis is often employed for disclosing unknown factors.

The process of finding the quantitative patterns of studied phenomena is most closely tied also to statistical analysis which, regardless of a whole series of shortcomings inherent to it (the necessity of obtaining information on a rather large number of uniform operations, the difficulty of obtaining objective data, and the limited nature of the natural variations of the situation), can provide very valuable results which are of independent significance. Thus, using statistical analysis during the years of World War II the problems were solved of the optimum composition of ships in a convoy, the effectiveness of arming submarines with homing torpedoes for hitting subchasers, the effectiveness of maneuvering ships in escaping from kamikaze attacks, and much else.

Nevertheless, the substantial limitations of the designated method necessitate testing, experimental exercises, maneuvers, and so forth. In the course of the testing it is possible to obtain numerical data on the dispersion, the probability of detection, the range and speed of movement. The same thing can be said on detecting the influence of changes in tactics, the properties of military equipment and the methods of its use on the results of combat. Regardless of the inevitable simplifications in the course of carrying out experimental exercises and maneuvers, the obtained results can be very valuable. Here the researchers are confronted with the possibilities of broadly altering the conditions for carrying out the experiment and, consequently, examining and establishing a broader range of possible parameters. Here it is important to bring the conditions for carrying out the experiment as close as possible to real combat and obtain reliable quantitative results.

The process of improving the mathematical apparatus plays a major role in broadening the possibilities of formalization, optimization and automation. The specific features of the processes investigated by military science, and in particular the theory of troop control, require the elaboration of a specific apparatus capable of adequately reflecting the studied processes. Consideration of these specific features cannot help but entail the rise of new original research methods.

The development level of the mathematical disciplines achieved in the course of the present-day scientific and technical revolution has prepared a sound basis for a quantitative description of the processes of armed combat. Mathematical methods are now becoming an inseparable aspect of the troop control process, and they are closely interwoven with such important elements of it as the evaluation of the situation, decision taking, and forecasting the results of combat. These help the commander to determine the balance of forces of the sides, to assess the combat capabilities of his own troops, to make an optimum allocation of forces

and means, to calculate the possible losses of personnel and military equipment, to assess the effectiveness of nuclear strikes, to solve the problems of optimum planning, target allocation, and so forth. It is essential to more widely employ these methods and technical means for realizing them. Control practices indicate that officers who have profound knowledge and rich experience in using modern mathematical methods and computers make full use of the enormous potential possibilities of the ASUV.

The effective use of the ASUV requires a developed, special mathematical support [software], that is, the early creation of complexes of mathematical models, algorithms and machine programs for solving typical and specialized problems which at the necessary moment can be used by a control body. A library of such programs should be constantly replenished and added to. This requires the presence of skilled specialists in the area of systems analysis, decision taking theory, and the mathematical methods of optimization, that is, algorithmists and programmers who have definite operational and tactical training.

Moreover, the effective use of automated systems and mathematical methods necessitates the corresponding mathematical training and work habits using computer information equipment on the part of the commanders and staff officers. The level of this training should be sufficient in order to make it possible for the commander to give a mission for formalization and solution on a computer, to determine the necessary data and criteria for evaluating the obtained quantitative recommendations in the final taking of a decision, and to see the strong and weak aspects of the employed mathematical methods. Here there must be knowledge in the area of decision taking theory, mathematical modeling, algorithmic languages and programming. This also necessitates definite skills, training, preliminary preparation, the preliminary calculating of a number of quantitative indicators, the compiling of calculations formulas, tables, graphs and so forth. Such diverse preparation makes it possible in the midst of combat to compare the existing situation with the previously calculated one, and on the basis of the quantitative characteristics of a similar variation, to rapidly take a decision which is close to the optimum. Of course, the possibilities of automation equipment and mathematical methods must not be overestimated. No matter how mathematics and computers develop, these possibilities are always limited. Even the most advanced mathematical methods cannot fill in the gaps in the knowledge of the very examined area. For this reason by using them it is not possible to surmount a potential limit of accuracy determined by the incompleteness of information, or by the presence of a large number of unknown, undetermined, random or hard-to-formalize factors. Consequently, the process of the development and elaboration of the mathematical apparatus is related to improving the operational-tactical apparatus. Both these processes should occur simultaneously, in parallel, under conditions of reciprocal influences and enrichment. Only the commander, in using all the diverse information, including that which cannot be machine processed, assesses

the combat situation, takes a decision, gives a mission to subordinates, and organizes the fulfillment of his decision, the fighting of the personnel for victory.

A victory cannot be calculated rather it must be won. Mathematical methods and electronic computers merely make it easier for the commander to take optimum decisions and carry them out efficiently. They are not in opposition to but rather combined with combat experience, the operational-tactical knowledge, reason and will of the commander. It would be wrong to assume that the extensive introduction of automation leads to a certain leveling of the human intellect. This is a profound error. Individual features and the difference of creative possibilities of the control principals will not be reduced but rather increased in the process of automation. In other words, the advantages of a creatively strong commander over a weak one will become even more apparent in the ASU. For this reason, with other conditions being equal, the most successful in combat will be the commanders who skillfully use the possibilities of modern mathematics, computers and automation.

In completing an analysis of the conditions needed for the broad and effective use of the method of mathematical logical formalization, we must again stress its very close link with the development of full automation and the introduction of the ASUV into troop control practices. In actuality, on the one hand, the desire to use computers for solving various problems of automation and optimization provides an impetus to the formalization of these problems, and on the other, it turns out that the possibilities for improving the automated systems depend substantially upon the successful formalization of the corresponding areas of control. The central methodological premise is the presently generally recognized notion that the aim of automation is not to replace man by a machine, but rather to bring about a maximum rise in the efficiency of control work. This, in turn, can be achieved only with a reasonable allocation of the control functions between the machine and man. In line with the need to determine for each specific instance the degree of the possible and advisable formalization, optimization and automation of the various functions of a person included in an automated control system, within human factors engineering there must be the systematic carrying out of quantitative research on the mental and psychophysiological possibilities of man.

Thus, a necessary and sufficient condition for the effective use of mathematical logical formalization for solving the problems of the optimization and automation of troop control is an improvement and development of military science as a whole, the elaboration of an operational-tactical apparatus for a meaningful description of the studied problems, the studying of the mental and psychophysiological capabilities of man using precise methods, the introduction of various methods and procedures for obtaining the necessary quantitative characteristics, interdependences and values of parameters, the elaboration of an adequate mathematical logical

apparatus, the broad use of calculators, and the presence of the correspondingly trained personnel. The aggregate of these conditions determines the specific possibilities of formalization, and consequently, the optimization and automation of the troop control process.

FOOTNOTES

1. Man acts as the modeling system in the process of cognition. Generally speaking, the role of a modeling system can be carried out by a living organism, a brain or computer, and on a wider basis, by any cybernetic system which is capable of receiving, storing and processing information and utilizing it for the purposes of self-regulation and control.

2. "Filosofskaya Entsiklopediya" [Philosophical Encyclopedia], Vol 3, Moscow, 1964, p 478.

3. See G. K. Zhukov, "Vospominaniya i Razmyshleniya" [Remembrances and Reflections], Moscow, 1969, pp 192-194.

4. "Issledovaniye Operatsiy na Praktike. Materialy Konferentsii NATO" [Operations Research in Practice. Materials of a NATO Conference], Moscow, 1962, pp 242-244.

5. See I. Anureyev and A. Tatarchenko, "Primeniniye Matematicheskikh Metodov v Voyennom Dele" [The Use of Mathematical Methods in Military Affairs], Moscow, 1967; V. Abchuk, et al., "Vvedeniye v Teoriyu Vyrabotki Resheniy" [Introduction to Decision Taking Theory], Moscow, 1972; V. Druzhinin and D. Kontorov, "Ideya, Algoritm, Resheniye" [Idea, Algorithm and Decision], Moscow, 1972; K. Tarakanov, "Matematika i Vooruzhennaya Bor'ba" [Mathematics and Armed Combat], Moscow, 1974.

6. V. I. Lenin, "Poln. Sobr. Soch.," Vol 18, pp 306, 313.

7. G. Klaus, "Kibernetika i Filosofiya" [Cybernetics and Philosophy], Moscow, 1963, p 227.

8. K. Marks and F. Engels, "Soch.," Vol 20, p 37.

9. See "Filosofskaya Entsiklopediya," Vol 2, Moscow, 1964, p 562.

10. V. I. Lenin, "Poln. Sobr. Soch.," Vol 29, p 301.

11. "Filosofskaya Entsiklopediya," Vol 3, p 329.

12. V. M. Glushkov, "Kibernetika i Umstvennyy Trud" [Cybernetics and Mental Labor], Moscow, 1965, p 19.

13. See B. V. Biryukov and Ye. S. Geller, "Kibernetika v Gumanitarnykh Naukakh," p 132.

CHAPTER 5: THE PLACE AND ROLE OF MAN IN AUTOMATED TROOP CONTROL SYSTEMS

1. The Problem of the Optimum Coordination of Man and Equipment in the ASUV

The recognition of the determining role of man in relation to any, including military, equipment is the basic methodological premise in solving specific problems in the ASUV. People create and use automatic and automated devices for achieving their aims in troop control. But in order for a person to hold a dominant place in relation to equipment, definite structural changes must be carried out in the equipment. The main purpose of the latter is to create favorable conditions for the effective activity of soldiers in the ASUV system. Such a complex problem in modern science has come to be called the problem of the optimum coordination of man and equipment. Its essence consists in the maximum adaptation of the ASUV components to each other for the purpose of increasing the efficiency of each of them and the entire system as a whole.

This problem assumes particular significance in the ASUV, where man acts in a single functional complex with a computer and other technical devices capable of assuming definite functions in the area of troop control. For this reason, before establishing the real ways for coordinating man and the technical device in the ASUV, it is essential to examine the possible variations for allocating functions among them, and to compare the possibilities of these components to carry out the basic elements of the control process. Here it must be pointed out that the relationship of the possibilities of man and the automaton may be investigated on the level of real or potential feasibility.

In modern scientific literature, attempts have been made to compare the possibilities of man and the automaton for processing information which is the basis of the control process.

The main qualities inherent to human activity.

1. A limited capacity, a small amount of information processed per unit of time.

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2. A reduction in work efficiency as a consequence of fatigue and the wandering of attention.

3. Comparatively slow and inaccurate carrying out of computational operations.

4. The insufficient (incomplete) use of information and a limited possibility of creating an integral notion of the phenomenon from individual events.

5. The ability to work in unforeseen situations, great flexibility and adaptability to changing external effects.

6. A broad opportunity for choosing the methods of action, speed in using reserves and correcting mistakes.

Basic qualities in the work of an automatic device.

1. A zero capacity for awareness; a careful programming of the structure of material.

2. Great complexity of programming, since it is difficult to foresee all the possible instances, and hence, to compile a program which foresees them.

3. Unsuitability for alternative thinking.

4. Virtually unlimited capacity.

5. A slow reduction in work efficiency.

6. Rapid and accurate execution of computational problems.

As for the quantitative characteristics of the abilities of man and a computer to process information, they have been given in a table the data for which have been borrowed from several works.[1]

A comparison of the possibilities of man and automatic equipment indicate that the most rational way for using the qualities inherent to each of these components is the creation of automated control systems. In them the man and equipment are united by common participation in the troop control process, and act as a single functional control complex, in complementing the capabilities of each other in performing specific control problems. The given notion has also predetermined the real ways for solving the problem of an optimum coordination of man and equipment, that is, "from equipment to man" and "from man to equipment." The first way consists in working out those design decisions in developing control equipment which would most fully conform to the psychophysiological and mental abilities of man who solves various problems using it in the process of

troop control. Such a progressive variation corresponds to the active determining role of man in relation to the implements of labor created by him in any area of activity, including in military affairs. However, such an approach to the problem of coordination cannot always be realized due to the various factors, for example, due to certain limitations in the development of science and technology.

Quantitative Characteristics of Human and Computer Data Processing

Parameters	Computer	Man
Switching elements		
Type	Diodes, transistors, ferrite cores, etc.	Neurons
Quantity	Up to 10^4	$1.5 \cdot 10^{10}$
Dimensions	10^{-2}-10^{1} cm^3	10^{-3}-10^{-5} cm^3
Response time	10^{-7} sec.	10^{-2} sec.
Memory		
Functioning Principle	Hysteresis of ferromagnetic materials	Change in synapses
Capacity	10^5-10^8 bits	10^9-10^{13} bits
Access time	10^{-8}-10^{+2} sec.	10^{-2}-10^{+1}sec.
Data input and output devices		
Type	Printer, punch, etc.	Receptors, muscles, glands, etc.
Quantity of data	10^2-10^6 bit/sec.	Unconsciously 10^9 bit/sec. Consciously (max.) 10^2 bit/sec.
Transmission rate	6,000 bit/sec.	10-30 bit/sec.

For this reason the necessity arises of realizing the second way of coordination, that is, "from man to the equipment," and this consists in adapting man to specific working conditions in the ASUV. Undoubtedly, joint functioning with an automatic device in a single control complex has a substantial impact also on man, in placing exceptionally high demands not only on his psychophysiological attributes, but also on the specific mental qualities, in determining the inner organization of his mental activity and requiring clarity of thought. All of this has required the adaptation of man to automatic equipment as expressed in the specific methods and procedures for training and instructing the personnel operating automatic equipment as well as in improving professional recruitment for work in the ASUV.

Although these two ways of optimum coordination are inherent to all types of activities of people in the ASUV, however the specific procedures and methods of realizing them are largely determined by the specific features

of those functions which the soldiers perform in relation to the automatic equipment. This necessitates an analysis of the functional structure of the troop collective in the ASUV for the purpose of establishing the most characteristic groups of soldiers operating automatic equipment.

The extensive introduction of automatic equipment into troop control leads to the development of ASUV the functional structure of which is an entire hierarchy of subsystems united by a common functional goal of controlling subordinate units and subunits which mutually coordinate their activities for ensuring the effective fulfillment of the missions assigned to them and are subordinate to a single commander.

At the same time, in addition to the personnel directly involved in the ASUV, it is completely essential to have a definite establishment of troops the functional duties of which are related to activities outside the given local systems. For this reason we can represent an automated control system as a certain single integral system around which all the remaining subsystems of the control body are grouped. This makes it possible to view the human material in the ASUV as a complex troop collective with an extremely developed differentiation of troop specialties in which a fundamentally new collective form of utilizing automatic equipment is carried out.

In the most general form, in the human material of the ASUV in terms of functional duties it is possible to isolate three basic groups of personnel: The group carrying out extrasystem functions; the group carrying out intrasystem functions; the so-called command group[2] (see Figure 4).

Automated Troop Control System
(ASUV)

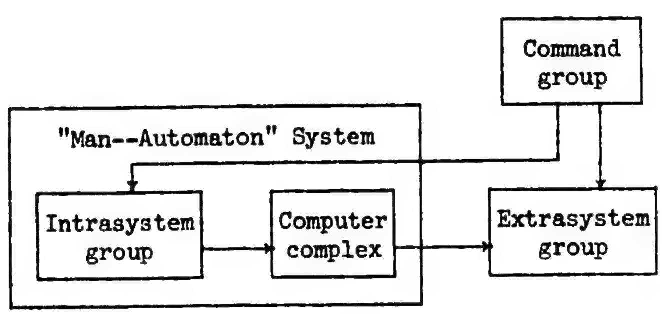

Fig. 4

The first (extrasystem) group brings together those specialists who are not directly involved in processing the information, but merely supervise the normal functioning of the automatic equipment and the computer

devices of the command post and the staff. This includes all the engineering and technical personnel which monitor the normal work of the system, which provides adjustment and repair of the equipment, periodic repairs and eliminates failures, as well as a large group of programmer-mathematicians. The specialists of this group are involved with all automatic equipment as a whole. They are in a way outside the process of processing the data flows which circulate within the system itself, they are next to it and monitor the correctness of data processing.

The extrasystem functions of man in the ASUV are marked by a great degree of creativity. Here in his activities are rather broadly represented all the basic functions involved in processing the information related to the state of the computer complex: its receiving, the taking of the corresponding decision and executor actions. The extrasystem functioning of man is characterized by the necessity of working in unforeseen situations, to respond quickly to signals, upon the indications of individual instruments to clearly visualize the overall picture of the state of the equipment, and so forth.

As a whole, the functional features of specialists in the extrasystem group are related to analyzing the reasons for the malfunction of computer equipment, and the organizing of the corresponding measures to localize the emergency and quickly eliminate it. The work of a specialist in this group entails involved intellectual activity related to responsibility for the normal functioning of the equipment and for the effective operation of the entire ASUV as a whole. An analysis of the basic functions performed by the group of extrasystem specialists makes it possible to isolate two basic forms of their activities:

1) The observation and monitoring of the normal work of the equipment and the consecutive analysis of information on the functioning of its basic elements under the conditions of the constant expectation of an emergency signal;

2) Activities in situations of an abrupt disruption of the normal functioning of the equipment. This requires an instantaneous analysis of the existing situation, an assessment of the nature of the emergency and the finding of the most effective methods of eliminating it.

Each of these two basic forms of activities by the men of the group of extrasystem specialists in the ASUV influences the coordinating of man with the automatic equipment, and determines the specific ways for creating the corresponding coordinating devices.

Of exceptionally great significance for ensuring the effective functioning of the ASUV is the group of intrasystem specialists who are directly involved in the process of processing the flows of information moving through the communications channels within the system.

The intrasystem activities of a man in automated control systems represent a completely new type of military activity and this has been terned operator work and is becoming the most typical at the present stage in the development of science and technology, in production and in military affairs. K. Marx described a man in such a situation as the "main agent" of a technological process and who (because of social or other conditions) is forced to be an attribute of the machine, to be turned into a "living automaton," to turn his body "into an automatically one-sided organ," and to act as "the automatic implement of the given particular work."[3]

The most specific trait of the activities of an operator in an automated control system is the difficulty, as a rule, of directly observing the actual controlled combat installations. For a notion of the real state of the controlled objects, the operator uses information received over the communications channels. From it he draws up so-called information models of the real objects and these are a structure of symbolic images organized according to certain formal attributes and reflecting with a definite degree of accuracy the properties of real objects and the relationships between them. The information received by the display devices including indicators and meters, requires a correlating with the real controlled objects. This process occurs in the stage of decoding the information and is the basis for taking the corresponding decision.

The activities of an operator with information models place high demands upon the data display devices by which these models are created. This, in turn, makes extremely urgent the problem of the optimum coordination of man with the automatic equipment in the process of the exchange of information between them.

An analysis of the intrasystem functions of man in an ASUV makes it possible to disclose a presently existing tendency for turning over these functions to an automatic device. Remaining for man are the creative functions of controlling the actions of the automatic equipment, checking the correctness of decisions made by the machine, their correcting in the needed directions, and so forth. All these operations are performed by specialists of the extrasystem group. Consequently, with a rise in the degree of automation and with the broadening of the capabilities of computers, there will be a gradual decline in the intrasystem functions performed by man in the ASUV. He will perform chiefly extrasystem functions. To this fundamentally new trend can be applied the words of K. Marx by which he described a similar process in the automation of production: man is put next to the production process instead of being its chief agent.

Thus, there is a tendency for transferring definite intrasystem functions of man to the automatic devices. In this manner there is a transformation of all the separate automatic assemblies for data processing in the control system into a single automatic complex. However full automation in no way leads to the separating of the relationship between man and

the automatic device. The integrated system is not broken up, but rather only the relationships between the components are altered in it, they become more flexible and to the greatest degree conform to the development prospects of the human personality. Man no longer is included in the data processing process as one of the elements which in all ways is similar to a technical element. He is freed from the necessity of being adapted to the technical devices and correlating his activities with their functions. Here the possibility arises of a rational allocation of functions between man and the automaton whereby only creative functions remain for man.

With a rise in the degree of automation in the system, the role of the extrasystem functions of the controlling principal, the functions of observation and monitoring, rises. The fundamental necessity of human control over the correct functioning of an automatic device exists at any, however high level of development in automation. A person included in the ASUV is a social being. This gives his activities a number of specific properties which cannot be fully modeled and turned over to a technical device.

Thus, the presence of social aspects in the activities of an individual is a decisive factor in allocating functions between the controlling principal and the automatic device as components of a unified system.

Let us examine the specific features in the functioning of specialists in the third group of the military collective of the ASUV who perform command functions. This rather sizable group plays an important role in troop control. It includes the officials responsible for the control of the subunits which are part of the automated system as controlled subsystems.

In the ASUV, this group plays a special role in relation to the two designated groups, the extrasystem and intrasystem. In participating in the general process of data processing, each member of the command group can be simultaneously the end element in the flow of initial information and the beginning element in the flow of command information the basis of which is the combat decision. This brings him close to the intrasystem group of specialists. At the same time, since the commander functionally and territorially is outside the limits of the "man--automaton" system, inherent to his activities are certain traits of the group of the extrasystem specialists. An important function of his is supervising the work of the entire system, and above all the activities of the two indicated groups.

In a general form the activities of specialists from the command group are related to the task of ensuring the taking of a combat decision. They clearly present the overall mission of the ASUV and the various aspects of its solution. This is provided by the presence of an internal conceptual model in a person, and this model contains a notion of the end result of the work of the system and controls the process of the transformation of

information by man. A member of a command group using the conceptual model formulated by him can evaluate the rationality of variations of a decision which are presented by the used system and which reflect one of the aspects of troop control. Here the problem arises of the relationship of the information model which is determined by the objective characteristics of the objects of control and the conceptual model which is a subjective plan of actions for the given chief. Precisely the conceptual model contains, in addition to the transformed data of the information model, a whole series of unformalized, creative and subjective aspects (a broader notion of the combat mission and its significance for carrying out the mission, an analysis of the consequences of implementing incorrect decisions, a readiness to correct them instantaneously and so forth) essential for controlling the troops. The specialists of a command group should play the decisive role in ensuring the effective functioning of the ASUV, since within the range of their functional duties and within the aspect characteristic for them they should participate in working out the combat decision. The quantity and quality of specialists in this group are largely determined by the organizational structure of the control body, by the volume of incoming information and by the specific features of the combat mission to be carried out by the controlled troops. At the same time it must be considered that the organizational structure of any control body is based on the principle of unity of command. All the men of the command group in their activities come back to the solely responsible commander and form a complex hierarchical structure which ensures centralized troop control. For this reason, in a general form the functional structure of the ASUV can consist of subsystems. Each of these is under a certain chief, and it supplies him with the necessary data for taking the appropriate decisions which subsequently serve as the basis for the taking of a combat decision by the solely responsible commander. Here the military leader of an element superior in the control hierarchy can assume control over several inferior elements and use the decisions worked out by them when necessary.

The command group of the ASUV should include the chief of staff who is responsible for its smooth and coordinated work. The chief of staff bears responsibility for organizing the information flows from the controlled objects, for the obtaining and processing of reconnaissance information, for carrying out measures related to all the basic types of combat support, and so forth.

In addition to the chief of staff, a command group can include a number of other officials. Each of them is responsible for a definite area of preparing the troops for combat, and for the effective functioning of the controlling body under him. Regardless of the diversity of duties, all of them are aimed at solving the single combat mission set by the commander. Within their rights and duties the officials evaluate the combat situation, they take a decision for the use of equipment under their control by the troops, they plan the preparations for combat, and they direct their subordinate services, relying on the control body at their disposal.

The command group must also include the party political apparatus which ensures the daily and integrated influence of the party on the life and activities of the troops, and firmly and consistently carry out the CPSU policy. The political bodies are confronted with the important mission of indoctrinating the personnel in a spirit of a readiness and ability to carry out the decision of the commanders, indoctrinating the men in a spirit of the ideas of Marxism-Leninism, total loyalty to their people, the motherland and the party, in a spirit of the friendship of the Soviet peoples, Soviet patriotism, high political vigilance and class hate for the enemies of communism, and in a spirit of a conscious fulfillment of military duty by each serviceman. Undoubtedly party political work under present-day conditions is also impossible without using calculating equipment which improves its flexibility and efficiency.

The introduction of automatic equipment into troop control not only does not reduce the role of the specialists of the command group in raising the efficiency of the troop control process, but also predetermines a rise in its significance. An automation of the data processing processes and above all the automating of the solution to numerous problems of a computational and reference nature can substantially facilitate and alter the work of the specialists in this group and make it more intellectual and effective.

Among the specialists of the command group, a special place should be held by the solely responsible commander who provides overall troop leadership. He bears full responsibility for the carrying out of the assigned combat missions. The commander in his actions in the area of controlling troop combat relies on his subordinate control bodies and above all on the actions of the command group. For this reason his ability to unify and organize the personnel to carry out the combat missions, and his capacity to rely on the staff, the party and Komsomol organizations are essential conditions for efficient troop control. At the same time, the commander bears sole responsibility both for his own actions as well as for the activities of his subordinate organs and troops. A decision taken by him to carry out the combat missions confronting the subordinate troops is the apex of all the work of the control bodies and is accepted for execution by all servicemen.

The isolating of the basic functional groups of personnel in the ASUV makes it possible to differentiate the general problem of an optimum coordination of man and automatic equipment in the form of solving three basic problems which correspond to the three basic groups of specialists.

As a whole, the necessity of the optimum coordination of man and a technical device necessitates a correlation between the data display devices and the sensory system of man. Here the properties of the indicators largely determine the effectiveness of human activities in detecting the signal, ascertaining its meaning, recreating missed or distorted information, and so forth.

Undoubtedly the various types of instruments used as displays possess varying visibility. For this reason the method and form of presenting information to a person should correspond to the nature of his basic functions in the ASUV.

Each of the previously isolated three basic groups of specialists in the ASUV requires the designing and use of specific data display devices.

Using the examples of foreign ASUV, let us examine the specific features of solving the problem of an optimum coordination of man and equipment in the carrying out of intrasystem functions by man. In these ASUV, the operator acts primarily as the receiver of information coming into him through the sensory channels of varying modality. Here the criterion for selecting the nature of the channel is its throughput data capacity as well as a person's reaction time to the given message.

According to the materials of modern research, the shortest reaction time in a man is to tactile, olfactory and vibration signals, followed by acoustical and visual.

At the same time, the foreign press has pointed out that the designers of military equipment often overload the visual channel and this leads to a decline in the efficiency of the operator's activities. As has been established by modern research, a person is capable of perceiving just 70 bits of information per second over the visual channel. Specialists feel that at present the possibility has appeared of distributing information evenly between the various sensory channels.

Thus, in using the property of the tactile channel which possesses the shortest reaction time, it is possible to place on the skin of the operator's arm instruments which would inform him of the position of the controlled object in the form of vibration signals.

Such instruments can also play a particular role in the ASUV in which the operator receives a large flow of information frequently requiring an immediate reaction.

The next fundamental problem which must be solved for the optimum matching of the human operator and the automatic device in the ASUV is the problem of the language of their communication. In the opinion of foreign specialists, one of the real ways for solving this problem at present can be the use of cathode ray tubes built into the computers and having a graphic display on which the operator graphically depicts the structure of the problem to be solved using a special light pencil. The automatic device carries out the necessary calculations, putting them out either on a punch tape or also graphically, and the research carried out has shown the exceptional promise of such a design, particularly in planning combat operations involving the use of maps, various diagrams, graphs, and so forth.

Let us examine the specific features of solving the problem of an optimum coordination with the carrying out of extrasystem functions by man. In this instance the basic tasks of a man are monitoring the operations of control equipment, ensuring the set operating conditions of the equipment, monitoring the quality of its functioning, preventing and eliminating emergencies, and so forth.

The problem of coordination obviously should consist of creating display equipment which would reflect all the particular features of the functioning of the technical devices in the ASUV and would make it possible for the person to carry out technical diagnosis and establish the reason and nature of the emergency.

In such an instance the development of displays which reflect the entire system of features in the functioning system can be of great importance for raising the efficient activities of man. Usually information on each most important parameter of a technical device is read off a separate instrument located on an instrument panel or control board.

In reading the indications from each separate instrument, a person should imagine a complete picture of the functioning of the technical device. However the possibilities of a person to read the indications from the indicators are rather limited, and an increase in their number merely impedes the functioning of the operator.

In the opinion of foreign specialists, this problem has assumed great significance in the ASUV with their cumbersome flows of very extensive information on the state of each of the functional assemblies of the "large system," where an entire establishment exists observing a specially equipped emergency board on which hundreds of instruments show the particular features in the functioning of the most characteristic assemblies of the equipment. Of course, under such conditions a mental synthesizing of their readings into a whole picture is virtually impossible. Specialists feel that at present, on the basis of the achievements in psychology and the development of equipment, it would be possible to develop indicators which provide a person with the basic parameters of the automatic device in the form of an already composed unified picture. In such an instance the person would no longer be concerned with a mental synthesizing of the individual elements into a single picture, as this is done for him by the instrument. Thus, several individual instruments which reflect the functional parameters of a technical device could be replaced by a single star the number of rays of which corresponds to the number of instruments, while the length, color and position of the rays provide information on the normal operation of the system. Here in the human mind an image of the star is reinforced and this reflects the optimum functioning of the computer, and by using the controls he endeavors to obtain this image, no longer comparing it each time with the specific conditions of the ASUV.

Thus, the problem of keeping track of the functioning of a technical device using a similar instrument would be significantly simplified and as a result of this the efficient activities of man in determining the state of the systems would be increased.

Let us examine the specific features of solving the problem of coordinating the command group. For taking a sound combat decision, the commander must correctly assess the problem situation and have a clear notion of the time-and-space position of the controlled objects on the spot. The realization of the principle of visibility in the display equipment in foreign ASUV is achieved by developing indicators of the plotting board type, mnemonic devices as well as using screen-type indicators which provide an all-round or sector view of space and on which the commander can visually represent the position of the controlled objects relative to the enemy.

Here the relationships between the objects are modeled in different sensory features of the display elements which create a dynamic picture, the subjective image of which is formed on the basis of the visually presented image of the combat situation and is used in taking a combat decision.

Under real conditions of a combat situation, the commander should, in addition, receive definite information on the characteristics of each controlled object and essential for solving a specific combat problem. Most often such information is provided to the commander by the staff in a verbal or written form. In the ASUV, for this purpose it is possible to use digital or alphanumerical forms which are displayed on the indicator next to the blip from the given object.

There is also another way of coordination, that is, from man to the automaton, and the essence of this consists in a certain adaptation of man to the particular features of the equipment.

The realization of this way also has its specific features depending upon the particular features of each of the three basic groups of the ASUV specialists.

Let us examine an example of solving the problem of optimum coordination in the event of the carrying out by man of intrasystem functions which have been most clearly expressed in operator work.

As a whole the conditions for the activities of an operator in the ASUV are completely determined by the great dynamicness and by the probability nature of a change in the combat situation. Abroad it is felt that operators can be exposed to stimuli related to the nature of the environment such as: A change in temperature, constant vibration, the effect of noise, and so forth. These conditions can have a substantial unfavorable influence on the human organism, in reducing the efficiency of its activities. It must be pointed out that the rigid limitaticns of the size of a

control board create serious difficulties for the rational placement of equipment and impede the operator's work.

All of this requires from an operator the development of such psychological qualities as the capacity to rapidly analyze the situation, emotional stability, the capacity to allocate attention, high sensory qualities and definite motor skills raised to the point of being automatic. For this reason, in professional recruitment for operator positions and with subsequent training, exceptionally high demands are placed on the servicemen. However, the most effective means for realizing this path of solving the problem of an optimum coordination is the training of the operator. In particular, this is manifested in the dependence of the reaction speed of the operator to the information content of the signal. Thus, in the first stage of training the reaction speed of a person depends upon the physical characteristics of the signal, and above all on the relationship of the signal to the background. In causing the orientation activity of an operator, this factor in a way conceals the information content of the signal, and this definitely tells on the efficiency of the operator's work. Under these conditions the operator begins to respond in the same manner to the appearance of a secondary signal, for example the blips from clouds, and to a signal of such enormous importance as information on enemy strategic bombers.

However, at a certain level of the operator's training, the possibility of the appearance of the given signal and the corresponding degree of its expectation become the basic determinant in the speed of his reaction. The dependence of the reaction time upon the information content of the signal has a linear character which is described by the so-called Hick's law. Here the operator considers the degree of importance of the information contained in the signal received by him, and his response time rises depending upon the degree of its importance.

In the course of further training of the operator, strong associative ties are formed between the displayed signals of increased importance and the definite reactions to them. As a result, the reaction time to these signals becomes constant. The operator who has achieved a high degree of training responds to the signals simultaneously. He has no need of making a choice between the information significance of the signal and the reaction to it.

The solving of the problem of the relative coordination of man and equipment assumes definite specific features in the event that the man or operator performs extrasystem functions. The work of the specialists in the extrasystem group under the conditions of the normal functioning of the system comes down to monitoring the operating conditions of the equipment. But in a critical situation, a rapid evaluation of the nature of the emergency and the taking of a decision to eliminate it are demanded from the person.

For carrying out these tasks the specialist in the extrasystem group should possess profound knowledge of the equipment, of the essence of the processes occurring in it and the interaction of its individual assemblies. He must also keep in mind a large number of quantitative characteristics of the different variables and parameters, and skillfully use them in making a technical diagnosis. This can be achieved both by the vocational selection of servicemen for work in the extrasystem group of the ASUV as well as by constant training for the purpose of maintaining the necessary professional skills brought up to the point of being automatic.

This way of coordination plays a major role in the event that in the ASUV the person carries out command functions. The working conditions of the command group necessitate the ability to rapidly evaluate a changing situation, and on this basis to take a sound combat decision and give it to the subordinate troops.

A person who performs the functions of a commander should possess the capacity for extended concentration of opinion, a great capacity of operational memory, a good sensory memory for complex signals, the ability to analyze space-and-time states of the controlled objects (and on this basis to take optimum decisions), decisiveness and an increased feeling of responsibility for the consequences of the taken decisions, and so forth. Here of particular importance is the ability of the commander to see the real objects behind the conditional signals, to recreate an integral picture of combat from the individual information signals, to select the best variation from all the solutions proposed by the automatic device and supplement this with the unformalized data. These abilities are considered in appointing a person to command positions in the ASUV and are constantly developed in the process of carrying out all sorts of training, games, exercises, and so forth.

Soviet scientists, in developing real ASUV, have endeavored to more fully utilize the truly human properties of the individual which contain inexhaustible reserves for his efficient activity as the principal of labor. For this reason, a solution to the problem of the optimum coordination of man and equipment should be aimed not only at raising the reliability and efficiency of the control system, but also at ensuring conditions for the development of the creative abilities of an individual.

The solution to this problem in military affairs has its specific features determined by the particular features of military affairs themselves and by those tasks which a person carries out in the ASUV. The carrying out of the principle of humanization is not always possible in solving the specific tasks of military technical designing.

However, Soviet developers of modern military equipment have constantly considered the specific influence of the individual qualities of the servicemen on the efficiency of military equipment, and have been

constantly guided by this methodological principle in using the achievements of modern scientific and technical progress for creating highly efficient ASUV.

2. The Influence of Individual Qualities of the Servicemen on the Reliability and Efficiency of ASUV

Being a most important element of the ASUV, man participates in a system not only as the carrier of certain professional labor qualities, but also as an individual organically linked to the troop collective, the army, all of society and its interests. In other words, in being an individual, a person is part of many of society's interrelated systems (subsystems) of varying complexity. For this reason the viewing of man as an element of the ASUV in a broader and precisely social context is an indispensable condition for a thorough analysis of the reliability of a control system.

In the works of bourgeois authors, the opinion is often voiced that the role of man in a modern war, particularly one using nuclear missile weapons, is determined solely by his professional and technical preparation. For example, the professor at the University of Michigan, A. Rapoport, in the book "Strategy and Conscience" thus describes the state and activity of a serviceman who has been turned into an attribute of the "weapons system": "He sits before the control board in comfort, like a clerk at his desk. He observes the signals which are totally devoid of drama and designating commands. He hears neither the noise of combat, nor the appeal to bravery and self-sacrifice. He is not asked to stand under the destructive enemy fire or attack the enemy. He obeys only the colored lights which flash on and off on the panel in front of him. The 'ideal' of a thermonuclear war means the complete automation of murder."[4]

Such a view of a soldier included in a "man--equipment" system is extremely one-sided and for this reason is methodologically unsound. Certainly the conditions of modern warfare have substantially changed. Now a serviceman does not always directly perceive his enemy, as they say, face to face. This, however, does not mean that he is indifferent to social and moral values (the aims of a war, its nature, the sense of one's life, goodness and justness).

The ASUV represents a complex sociotechnical system the reliability of which depends not only upon the perfection of its technical element but also upon the social maturity of the people operating the system and controlling the equipment. Marxist researchers who are working in the area of ergonomics (an area of scientific knowledge concerned with studying the interaction between man and equipment) consider this notion to be methodologically fundamental in determining the ways for increasing the reliability of the ASUV.

In analyzing the human element of the ASUV, until very recently the greatest attention has been given to the psychological aspect per se. In the

opinion of certain scientists, "psychological problems of the automation of industrial control comprise one of the areas of future economic psychology."[5]

However, comprehensive research on man generally and man as an element of the system examined by us, in particular, is possible only within the limits of Marxist-Leninist philosophy. This in no way does away with the special methods of studying man. The philosophical approach "is of determining methodological significance for all others. In the first place, it formulates the general methodological and ideological set in studying such a complicated and many-sided phenomenon as man. Secondly, in being based on special sciences of the system of human knowledge and its synthesizing possibilities, it contributes to the development of an integrated notion of man."[6]

Due to the fact that in Marxist literature a uniform understanding of the structure of a personality and its qualities has not been achieved, it is advisable to give one of the possible variations for solving this problem, and on its basis disclose the basic lines for the impact of man on raising the reliability of the ASUV. Naturally the behavior of man and his activities within the ASUV are subordinate to the general patterns which determine his behavior and activity. This can only be a question of the specific behavior and activity determined by the particular features of functioning in the ASUV as well as the interpersonal relationships formed in it.

In a man who represents a dialectical unity of two principles--natural and social--there is the development of all the components and their properties following two programs--genetic and social. In realizing a genetic program, man develops as a biological species and is subordinate to the patterns of highly developed living beings. "...The very fact of the origin of man from the animal world," wrote F. Engels on this question, "determines that man will never be completely free from the properties inherent to an animal...."[7] Obviously there is inherent to man a complex of biological (natural) qualities manifested in his functions as a living being (irritability, biological adaptation within certain limits to changes in the environment, fatigue, the ability to restore vital functions, and so forth).

Also inherent to man is a complex of qualities formed under the effect of the genetic program but altered under the conditions of social development. These include: The selective capacity of the analyzers to perceive signals from the outside, attention, speed of motor movements, and so forth. The history of the biological adaptation of man to the environment which has occurred over hundreds of thousands of years as well as social experience are reflected in their formation. According to the information of the well known English physiologist, one of the pioneers in electroencephalographic research on the brain, Walter Grey, the electric activity of the brain in so-called identical twins in a state of quiec is maintained for

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years, that is, is marked by great stability. However, in the responses to stimuli in accord with the different social experience of these twins, noticeable differences are observed in the patterns of electrical activity in their brains.[8] For this reason, a number of the mental qualities of man, although predominantly determined by the genetic program but also modified under the effect of the social program, should be termed bio-social qualities. Undoubtedly the particular features of the biological and biosocial qualities of man determine his reliability as an element of the ASUV.

At the same time, man possesses qualities which he acquired in the process of assimilating social experience, in the accumulating of material and spiritual values and in the manifestation of his social activity. Precisely these qualities determine the essence of man as an individual. "...The essence of the 'particular individual'," wrote K. Marx, "is not in his beard, not in his blood, and not in his abstract physical nature, but rather his social quality...."[9] The qualities of a person as an individual have come to be termed individual qualities. These are ordinarily divided into physical and spiritual. The former arise on the basis of natural properties and characterize man precisely from the social aspect. They consist in his physical endurance, work efficiency, the ability to regulate the expenditure of his physical energy, to coordinate body movement, to direct the activities of analyzers in accord with the set goal. The movements of the hands of a surgeon, a composer or a setter on an automatic line are not only and not so much the consequence of a gift of nature as a result of skills acquired in the process of social practice. Physical qualities are an inseparable component of the individual. Thus, K. Marx, in describing the individual qualities of a worker, also pointed to his physical capacities which he considered to be determined social qualities.[10]

In participating in the ASUV in the role of an element in it, a serviceman broadly applies his physical individual qualities. His ability to endure physical stress, to work productively under the conditions of modern combat, to promptly overcome apathy and maintain attention under the conditions of the lack of active stimuli, and to master the equipment--all of this is acquired in the process of long and specific training.

The spiritual qualities of the individual are marked by a significantly more complex structure. By them a person carries out the following functions: Cognitive-informational (a selective attitude toward the ordinary flow of information, an evaluation of its significance, systematization, storage and reproduction as it is needed); creatively constructive (the ability to make jump in cognition, to go beyond the limits of the patterns and automatic actions developed in the process of training and self-instruction); regulative (the capacity to influence one's activity and behavior, proceeding from existing knowledge, convictions, strength of will, developed habits, the clash of motives and mood); communicative (the capacity through various sign systems to transmit the content of one's thoughts, desires and experiences to other people, as well as

perceive the significance of the signs which others use); emotional-sensory (the capacity to experience all acts of vital activity).

All the qualities of man are intertwined into the social activity of the individual who does not act just as the spiritual or exclusively as the physical, but rather is a synthesis of both. However the concrete type of an individual's activity can be related to the predominant expenditure of spiritual or physical efforts. This circumstance makes it possible to conditionally term certain types of activity as predominantly mental or physical labor.

Depending upon the spheres and nature of applying spiritual and physical forces of the socialist type individual, it is possible to isolate the following complexes (groups) of its qualities: Sociopolitical (loyalty to the cause of communism, socialist patriotism and internationalism, intolerance of social injustice, and sociopolitical activity); professional-labor where military qualities are a specific variety (competence, labor activeness, and so forth); family-domestic which realize the rights and duties of an individual in relation to other members of the family, relatives and neighbors; cultural-aesthetic (general education, the ability to use cultural values and participate in their creation); moral qualities (the attitude toward moral values manifested in the conduct of the individual).

In permeating all other qualities and in possessing the capacity for integrating them, moral qualities usually act in combination with them (moral political, moral labor, moral combat, and so forth). Cultural and aesthetic qualities possess the same property.

All of these spiritual qualities of man gain their integrated embodiment in his ideology which is an integrated system of views on the world around (reality) and his place in it. However an ideology can be ordinary (formed in the process of daily practice and contact with other people) and scientific, including idealistic or materialistic, religious or atheistic, and so forth.

In the armies of the socialist countries, a scientific communist ideology is constantly and steadfastly instilled in the servicemen. Its influence on the activity and conduct of the individual is so great that the 24th CPSU Congress defined the task of developing a communist ideology in all workers as the core of all the party's ideological and indoctrinational work.[11] This thesis was also reflected in the decisions of the 25th Party Congress.

A scientific ideology of the individual[12] represents a system of dialectical materialistic (philosophical), economic and sociopolitical convictions and assimilated fundamental conclusions of social and natural sciences which provide an integrated and adequate notion of the world and the place of the individual in the struggle for social progress and communism.

Consequently, with the present level of the development of knowledge, it is impossible to speak of a scientific ideology of an individual if it has not mastered Marxism-Leninism as the basis of this ideology. At the same time, a scientific ideology cannot be considered complete if the individual, along with this basis, has not assimilated the fundamental conclusions of the natural (physics, biology, astronomy, and so forth) and social (law, ethics, aesthetics, and so forth) sciences. Ideological knowledge gains true force and causes the individual to become sociopolitically active in the struggle for communism only when this knowledge becomes its conviction and its internal moral sets.

Philosophical and sociological knowledge and convictions which are one of the components of the scientific ideology help a person participating in ASUV to more profoundly understand the relationship of objective conditions and the subjective factor and the laws of armed combat. The individual who does not know these laws feels himself to be the pawn of unbridled forces on the battlefield or in one or another section of the ASUV, and does not have confidence in the possibility of subordinatihg circumstances to his will. On the contrary, philosophical and sociological convictions make it possible for a soldier to have confidence in himself as the creator of circumstances and impel him to maximally manifest his activeness.

Having assimilated scientific sociopolitical knowledge, a serviceman clearly realizes that the policy of a state, being the concentrated expression of the economy, can be just or injust, and that the expansionistic nature of imperialist wars is ultimately determined by the selfish interests of the ruling classes. In having a decided influence on the process of armed combat, new weapons cannot alter its political content. For this reason the soldiers of a socialist army engaged in an ASUV are convinced that wars in the defense of the victories of socialism always have a progressive bent and a just character. Conviction in the justness of a war, as V. I. Lenin stressed, "raises the morale of soldiers and causes them to endure unheard of hardships."[13] This is a pattern common to all servicemen.

Legal knowledge helps a soldier who is carrying out the role of a definite element in the ASUV to understand the sociopolitical nature of war from the viewpoint of its legality; aesthetic knowledge helps understand the elevated goals of a war in the defense of the victories of socialism.

Thus, ideological knowledge hones the social awareness of a soldier, and develops in him a hate for those who are encroaching on the victories of socialism, and they help him feel his involvement in the fate of the motherland and personal responsibility for its defense. Ideological knowledge makes it possible for the soldier to go beyond the specific situation in which he is one of the elements of the ASUV, and see his role from the heights of a scientific ideology. In this instance the humble role of a component of the ASUV appears in a different light, and assumes a

more profound social content. Certainly this tells on the attitude of the soldier to his immediate duties.

Ideological knowledge and convictions in military personnel are objectified and gain a material embodiment in their actions and deeds which, in turn, show the professional and labor qualities of the individual. Although the latter differ little from the analogous qualities of specialists working in national economic automated control and service systems, however they are realized in specific and rapidly changing situations of armed combat. Under these conditions the enemy can impede or completely disrupt control. Moreover, the circumstances of combat strictly limit the time for a person to take a sound decision, and create a constant danger for life.

The military qualities of servicemen engaged in an ASUV depend to a significant degree upon the training level, experience and skills in using equipment. In turn, the effect from the manifestation of military qualities is determined by the scientific organization of labor of all the servicemen employed in the ASUV. It is generally known that the NOT is determined by the conformity of the organizational forms of human activity to the laws of this activity. In terms of the ASUV, this means to what degree the organizational forms of the activities of the men correspond to the laws of the successful functioning of the control system. NOT includes a system of intercoordinated measures which permit the constant maintaining of high combat readiness and capability of the servicemen, and the ability to attain maximum results with minimum outlays of time, mental and physical energy of the servicemen, the least losses in personnel and equipment, optimum use of the equipment, and the constant maintaining of it in operational readiness.

An improvement in control is tied to a further improvement in the automating of control processes and control qualities of the ASUV leaders as well as all the servicemen working in it. The ability to plan one's own activities and those of subordinates, to foresee a change in conditions, and to optimally allocate one's forces and means in accord with the general and particular tasks is not acquired all at once. Under combat conditions, the reliability of the ASUV will be higher the more complete the control qualities of the commanders. One of the widely found shortcomings in the control of ASUV is the inability of the commanders of individual elements in the control system to optimally allocate the load (duties). Most often the greatest burden falls on the commanders and the chiefs of staff. There have been frequent instances when under the condition of continuous "battles" (exercises) after a short period of time they were completely unsuited for work. Undoubtedly it is impossible to evenly distribute the load due to the different functions performed by the officers. Here the basic task is a desire to match the load on the servicemen to the level of their preparedness, their psychological and physiological capabilities and their functional duties. Skilled specialists at times experience an uneven load when they are improperly used.

The family and domestic qualities of the servicemen have an indirect influence on the reliability of the ASUV. The information received by the servicemen from home has a significant psychological impact on their attitude toward carrying out their duties. Consequently, the reliability of the ASUV cannot be restricted to just military technical knowledge of the operating personnel.

Cultural and aesthetic qualities of the individual also have a great effect on the reliability of the ASUV. The concept of cultural and aesthetic qualities is used in a broad and narrow sense. These qualities (in the broad sense of their understanding) manifest the attitude of the individual to society, to individual elements of its social structure, to the artificially created objective world, toward material and spiritual values as well as toward nature. Here it is a question of social man who possesses "the richest possible properties and relationships."[14] In the narrow sense, cultural and aesthetic qualities of an individual designate its capacity to carry out its daily activities, to organize its relations with persons in direct contact with it, proceeding not only from purely utilitarian (considering exclusively practical benefit) considerations, but also on the basis of the laws of beauty. Precisely on this level the monograph will deal with cultural and aesthetic qualities of the individual which are clearly apparent in its ability to bring the content and form of its activity to harmony and perfection, and to feel and sense the measure in communication, actions and deeds. Within the limits which cultural and aesthetic qualities involve the sphere of communication between people, they merge with the moral qualities of the individual. For this reason, in the given instance it will be a question solely of the influence of the cultural and aesthetic qualities of an individual on its attitude toward technology.

The ability to perfectly use equipment in the ASUV depends both upon the general and special training of the servicemen. "...In order to use a multiplicity of things," wrote K. Marx, "a person should be capable of using them, that is, he should be a highly cultured person...."[15] The level of servicing equipment presupposes a coordination of the psychophysiological qualities of the serviceman with the equipment whereby its optimum measure is found in relying on the reliability of the equipment and bringing to perfection the skills of the serviceman as an element of the ASUV. It is impossible to deny the positive significance of automatic responses and definite patterns in the actions of servicemen operating equipment. In them is accumulated an extended process of the adaptation of man to a specific piece of equipment and the search for the measure of the technical level of the individual.

The cultural and aesthetic qualities of a serviceman engaged in an ASUV serve as an indicator of the perfection of NOT achieved in a specific area of the control system. These qualities are manifested in numerous "details" from which the functional activity is made up. These include: The organization of working and resting conditions, the preparation of

the work area, and so forth. Even the correctly found stance of a serviceman at his work area can be a reserve for increasing labor productivity. A specialist who has mastered the equipment works not merely effectively but also beautifully and artfully. If the individual has developed a feeling for the beautiful, then it undoubtedly is also felt in the work. Carelessness, sloppiness, an absence of punctuality and preciseness, untidiness in work, on the one hand, and beauty, on the other, are incompatible.

The formation of the cultural and aesthetic qualities of an individual occurs in the process of daily activity, in contact with other persons and particularly in perceiving sensory and visual works of art. A high aesthetic culture of a soldier is not an impediment but rather a powerful catalyst for the successful fulfillment of his functional duties as an element of the ASUV.

A serviceman in an ASUV can work autonomously or in contact with other persons. Whatever the degree of spatial contact of a soldier (through the equipment or direct communication), he is linked with them as a member of the military collective. A military collective is a specific variety of a labor collective which represents a basic cell of a socialist society.

The place of a labor (including military) collective in the social structure of a socialist society is determined by the contribution of each individual to the creation of the material and spiritual values, and to their multiplication and defense. The moral merit of a person is materialized precisely in the active, creative and military spheres and he is formed as an individual. In a labor collective a person realizes both his rights and duties as a citizen and a member of various social organizations (party, Komsomol and trade union). A labor collective has a constant indoctrinational influence on individuality. In it the new, socialist qualities of the workers are formed and the attitudes of friendship and comradely mutual aid are established.

The regulation of the relationships between the members of military collectives, including those which form the ASUV, is carried out by social standards or norms (the demands made on the individual). The fundamental portion of them is established in enforceable enactments (laws, manuals, instructions and orders). However, all social norms, regardless of their official legal reinforcement, are based on the strength of social and collective opinion, and the self-awarness of the individual which is formed under the influence of both objective conditions as well as all forms (types) of social awareness (political views, legal awareness, morality, aesthetic and other views). The moral and political views of the servicemen have the greatest impact on their behavior and on the relationships between them.

The special place of moral and political views in the system of controlling the behavior of servicemen is explained by the following factors.

In the first place, in moral views and standards, in contrast to others (for example, scientific), behavior is reflected in the most concentrated form. For this reason, at times the sphere of behavior is viewed exclusively through the prism of morality (such an approach toward behavior is far from complete). Secondly, the activities of the servicemen in their specific manifestation, as representatives of a state body, are political activities. They directly realize one of the foreign policy functions of the state, and for this reason in their awareness political views cannot help but hold a determining place. Consequently, such moral qualities of Soviet military personnel as patriotism and internationalism are simultaneously political ones. Loyalty to the cause of communism and love for the socialist motherland and the socialist countries are an integral moral-political quality characterizing the personality of a soldier of a socialist army generally and one employed in an ASUV, in particular. However perfect professional and labor (military) qualities a serviceman may possess, in and of themselves they are insufficient to ensure the reliability of his activities as an element of the ASUV. Special professional training may have a negative effect if this instruction is not accompanied by and strengthened with communist indoctrination. One must not be set in opposition to the other. Loyalty to the cause of communism and love for one's motherland and the socialist countries are realized specifically through the attitude of a soldier toward the execution of his functional duties.

The communist attitude toward labor on the part of military personnel employed in an ASUV means: An awareness by them that their duties to a higher degree are useful and socially necessary; the perfect mastery of their functional duties; the constant ensuring of functional reliability of that element of the ASUV which has been assigned to the various servicemen; a maximum providing of help to one's comrades in the interests of maintaining the reliability of the entire control system.

No matter how perfectly an individual serviceman employed in an ASUV carries out his professional duties, the reliability of the entire control system depends upon the synchronization and the reciprocal coordination of all its elements. Moreover, the reliability of an ASUV as a whole is determined by the reliability of its weakest link. For this reason, the efforts of the entire collective aimed at maintaining the high reliability of the control system may not provide the expected results, if the corresponding reliability is not provided in all the sections of the ASUV.

A solution to the problem of ensuring high reliability of the ASUV depends not only upon the maintenance of the equipment in a working condition, but also upon the moral and political qualities of the servicemen in the sphere of the ASUV, upon their awareness, morale, and the feeling of collectivism and responsibility for the common cause. The responsibility of each to the collective and vice versa becomes an inseparable trait of our way of life and an imperative of the times.

The shaping of an awareness and feeling of collectivism occurs in the process of the entire vital activity of an individual in a socialist society. However, the degree of collectivism, as an individual quality in military personnel, is not the same. For this reason, the commanders, political workers, all the indoctrination officers, the communist and Komsomol members engaged in the ASUV endeavor not only to develop collectivist qualities in the men but also to further their set for self-indoctrination.

One of the specific features in the activities of military personnel engaged in the ASUV is related to the ongoing scientific and technical progress leading to ever greater spatial autonomy and isolation of one another. In certain areas of the ASUV, a serviceman works surrounded only by equipment and does not have an opportunity to directly observe the activities of his comrades. This objective trend causes a shifting of the perception of combat from the sensory sphere into the intellectual and rational area. Depending upon individual qualities and upon the strength of imagination of the men, in their awareness nonidentical information models of combat arise. One soldier clearly sees the panorama of the engagement behind the readings of the indicators, and is clearly aware of all the difficulties which have befallen his comrades, while another may not have such images.

Compensating for the informational and sensory starvation in soldiers engaged in ASUV is not an easy problem. Its solution is complicated by the fact that the communications channels of the ASUV are completely filled with operational information directly linked to the carrying out of specific combat missions. Moreover, all messages circulate in a coded form. The use of these communications channels for informing the men of the moral state of comrades, their mood, heroism and courage is extremely limited. The lack of such information weakens the feeling of closeness and empathy and one's involvement in the fate of the collective. This problem can be solved by employing various forms and means for indoctrinating a feeling of collectivism in the men. The most effective are direct contact, the listening to reports of subordinates on their mood and state of mind, as well as messages on the state of affairs within the entire ASUV, the prompt supplying of newspapers, pamphlets, photographs, tape recordings and so forth to the men.

Certainly, these measures will produce a proper effect in the instance that collectivist sets have been shaped in the men prior to their entry into the ASUV. For this reason, it is advisable to select personnel for carrying out strictly autonomous (in the spatial sense) tasks in the control system considering the formed collectivist qualities of the servicemen.

Even the most intensive and accelerated operating conditions of the ASUV do not prevent the personnel engaged in its individual elements from meeting periodically in full strength or with representatives at party and Komsomol meetings. Personal contact is a very effective means for

indoctrinating a feeling of collectivism and responsibility for the functioning of the entire ASUV in the men. At the same time, such meetings in a combat situation require careful preparations and consideration of the conditions which exist on the battlefield. For this reason the men in the ASUV can often function under stress conditions. A dangerous situation is reflected in their feelings, it causes negative emotions and tells on their mood. Under these circumstances, only collected, morally strong and strong-willed soldiers can resist panic, the feeling of fear and bewilderment.

Will is the capacity of conscience to regulate and control the behavior of a person, and is the concluding element in mental activity, when thoughts and feelings turn into the actions and deeds of an individual. Will possesses relative independence in relation to ideology. A strong will (like a weak one) can be inherent to persons with both progressive and reactionary views. This circumstance cannot help but be considered in ensuring the reliability of the ASUV.

Will is formed in an individual in the process of instruction, indoctrination and particularly self-indoctrination under certain conditions, in the process of overcoming difficulties and victory over oneself. Will has a varying focus. A person can possess a strong will causing one to show a steady interest in training exercises, physical exercises or mental labor, and at the same time have a weak will for decisive actions in a dangerous situation. For bold actions in a dangerous situation it is essential to shape the moral and volitional qualities of military personnel under conditions close to actual combat. A strong will gives a soldier confidence, it helps to overcome the feeling of fear, and makes it possible to act decisively with unexpected changes in the combat situation. For this reason the tempering of the volitional qualities of servicemen involved in a control system is an important direction of preparing them to fulfill their functional duties within the ASUV.

Thus, the professional and technical qualities of an individual, its special knowledge and training are a very significant factor but far from the only one influencing the reliability and efficiency of the ASUV. All the social qualities of the individual are closely interrelated. For this reason the solving of the problem of the reliability of an ASUV cannot be considered sufficient if it is restricted merely to the special training of the personnel. All the social qualities of the individual must be developed. Only under this condition can the reliability of the ASUV in its human element be considered ensured.

3. The Creativity of the Commander and the Automation of Troop Control

One of the urgent methodological problems brought to life by the military and technical revolution is an examination of the relationship of creative thinking by the commander and the electronic computer in the ASUV. In elucidating these relationships, inevitably different views have arisen.

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Some researchers have placed fundamental limitations on the path of using electronic computers in troop control. Their basic argument is that the creative portion of a commander's job cannot be automated. Others have recognized the fundamental possibility of formalizing the creative activity of a man. In their opinion, in military affairs intuition will be replaced by "precise calculation."

At present basic attention is rightly being focused on the questions of an optimum combination of the activities of man and the computer in modern control systems, and the computers are viewed as a means for broadening and strengthening the creative possibilities of the commander. In this regard greater interest has been shown in elucidating the essence of the creative activities of man, and in defining the content of such categories as "creativity," "search," and "intuition" of a commander. The difficulties of solving the given problems are related not only to the insufficiently examined "mechanisms" of human conscience, but also to the close intertwining of the discursive and intuitive in the thinking and activities of man.[16]

Since thinking arises and develops in the process of labor activity, to one degree or another this has a creative nature. At the same time not each task carried out by man is a creative one.

In particular, creative tasks can arise on a basis of contradictions between the goals and desires of a person and the means of attaining them which are insufficient or unknown at the given time. These contradictions cannot always be solved on the basis of ready-made rules, instructions or advice. Creativity presupposes the resolution of the contradictions and the creation of something fundamentally new, let this be either the result or the very method of obtaining this result, or both taken together, that is, what did not exist previously at all. Such a definition makes it possible to emphasize the fundamental newness of the creative product. It is important to disassociate this from an understanding of the new in the sense of the result of conveyor or routinized production of new objects, things and ideas. In being new in terms of the result of the transformation of matter, each article which follows the prototype is a precise copy, a reprint of the preceding and in this regard is old. This is precisely fixed in the phrase: "Although the machine is new, the model is old." For this reason creativity must be understood as a process of thinking and activity which is characterized not simply by a new result, but rather by a fundamentally new, "previously unknown or nonexistent result."

Of course, such a categorical criterion for the result of creative activity is of significance only as a principle. Certainly the degree of newness of the result and, consequently, of the creativity in the specific types of theoretical and practical activity can be extremely different. This circumstance finds its corresponding expression in the concept of "craft," "art," "invention," "rationalization," "talent," "geniality," and so

forth. For this reason the amount of a personal creative contribution to the activities of various people can fluctuate almost from zero to high limits.

Creative and uncreative activity are not isolated from one another by a Great Wall of China, for the elaboration of the rules for solving a problem shifts the latter from the category of atypical and creative to typical and uncreative. This pattern underlies the further broadening of the possibilities of computers which are being given ever new problems for solving, and the algorithms for these problems have already been found. At the same time the concept of "fundamentally new" is always taken in a concrete relation to definite persons, social strata or classes. When it is a question of the fundamentally new, involuntarily the question arises of for whom it is such. Is this for all mankind, a class, a state, a group of people or for me alone? Consequently, creativity, as thought and activity in the process of which something fundamentally new is created, can be assessed on two and more levels, that is, in relation to a definite social group or even to all mankind.

Creativity in military affairs bears the imprint of the complexity and certain mosaicness of military affairs themselves which include the different sectors of military labor. In any sphere the soldiers are confronted with missions which do not have ready-made rules for solving them. In automated systems the degree of the creative participation of the various groups of personnel in the functioning of the ASUV varies (the extrasystem, intrasystem and command groups). In analyzing the balance of the creative activities of man and the computer in automated systems, it is advisable to understand by "man" the degree of the creative involvement of people in working out the programs and preparing the computer for operation, in the process of its operation and in taking the decision.

Creative thought in the process of solving untypical, original problems relies both on the formal logic as well as intuitive heuristic methods. The former consist in certain operations of thought, including: Analysis and synthesis, induction and deduction, comparison, abstraction, and so forth. The latter presuppose the capacity of thought for imagination and intuitive leaps. These methods are in a dialectical unity, and in the various stages of the process of cognition and problem solving, one or the other assumes predominant significance.

To the degree that a computer models primarily discoursive, reasoned thought, it is important to analyze the balance of these methods in the ASUV, to study the potential possibilities of modeling creative processes, to trace the dialectics of the transition of creative problems into uncreative ones, and on the basis of the obtained results, to clarify the possibilities of the further introduction of automation in the various stages of the commander's activities in the area of troop control. At each of the stages, the balance of the creativity of the commander

(officer) and the work of the computer equipment varies. The degree of automation for each operation in the chain of consecutive operations in working out a decision depends upon a number of principles. The most important of them is the following: the machine is given what it does better than man. The concept of "better than man" includes primarily the indisputable advantages of the computer in speed and accuracy of calculating. The creative thought of man has enormous advantages over the computer, and includes: The capacity for initiative, the setting of tasks, the working out of intelligent decisions with insufficient data, the generalizing of concepts, the capacity for intuition, and the possibility of volitional and emotional activity.

For graphicness it is possible to examine the basic cycles in the mental activity of a commander.

The first stage--the explanation of the combat mission--remains almost completely the privilege of the creative thinking of a military chief. The commander endeavors to penetrate the plan of the superior chief. If it is a question of a regimental commander, then he ascertains the place of the regiment in carrying out the combat mission of the division. Here he creatively processes the received information (the order of the superior chief) and thinks out its basic provisions. As a result of the mental activity, new information is elaborated, and the task posed by the senior chief is remodeled by the commander. The problems of goal setting and goal fulfillment assume the necessary concretization considering the combat experience, knowledge, character and temperament of the commander. The process of elucidating the combat mission is not only related to the reasoning out of the obtained information, but also to the necessary generalizations and the posing of new problems. All these aspects are creative acts of man alone. Although self-instructing machines do work out programs for their own actions, man still stands at their sources.

The elucidation of a combat mission is a most important prerequisite for using a computer in the process of collecting and processing information as well as for selecting the optimum variation of action. Certainly even the most perfect mathematical apparatus or an electronic machine will not help if the commander has not elucidated the essence of the combat mission, if he has not formulated the goal of the actions or determined the basic parameters for the forthcoming battle or operation. For example, at one time in the United States certain types of tactical testing of the ASUV were aborted due to the incompetence of the programmer mathematicians in military affairs. They had completely mastered mathematical logic, mathematical statistics, game theory and algorithm theory, but were unable to work out the methods for solving tactical and operational problems and an operating program for the computers on the staffs.

In elucidating a combat mission, the commander determines the volume and quality of information needed for working out a plan of the decision, and designates the work procedure in the second stage involved in the collecion and processing of operational and tactical data. The collection of

data needed to elucidate the mission and take a creative decision is not purely a technical problem. It presupposes without fail active creative search, and a desire to solve the problem on the basis of a minimum of information. Under the conditions of the present-day scientific and technical revolution and a definite information "explosion," it should be a question of the optimum parameters of the quantity of information needed for solving a creative problem. On this level a man can solve the problem of collecting and evaluating data "more economically," for in an individual fact he is capable often of seeing more than a computer can. In the very perception of the world by a man there is a creative principle and a capacity for selectiveness in depicting the world and a semantic evaluation of the perceived facts. However, with a rise in the amount of information needed for the correct creative solution to a problem, human thinking cannot always handle its processing. Here machines come to help and they provide a speed which is inaccessible for human thought.

At present there has been a continuous increase in the amount of data received by the commander and a shortening of the time for processing them. Here one must note the essential difference between the information capable of providing an answer to the arisen question and that raw material from which information must still be extracted. Some researchers have proposed that this raw material (in contrast to effective information) be termed simply data. Others call it primary information. But they all emphasize that with an abundance of primary information, a "information starvation" develops. This is caused by the limited possibilities for human thought to process directly the entire bulk of incoming data. Even a creative mind hesitates when confronted with the avalanche of data which should be systematized, analyzed and evaluated before use. Often with an abundance of primary information, a lack of the most important data is felt dealing with the enemy, its position, fighting strength, condition and intentions. As a result, creativity loses its gnoseological base, that is the correct reflection of reality. Consequently, under present-day conditions the most important prerequisite for creative decisions is the turning over of the most labor intensive work of locating, collecting and processing the information to equipment, and primarily the cybernetic machines which complement man in creativity.

However here as well the involvement of man is required in preparing their activity. Only creative thinking by specialists on the basis of existing experience and knowledge can determine ahead of time what data on a combat situation are required and provide this in the machine program.

The commander sets the criterion for the suitability of information, and only he and his staff in the concluding stage evaluates the data processing results. In other words, an interaction arises between man and the machine, and in this man maintains all the creative work of preparing the computer for operation and interpreting the results obtained by it.

As is known, the results of the processed information can be obtained by the commander on a display screen in the form of diagrams, tables, graphs and so forth. However the image on the screen is a schematic one, without details. No program can provide for the displaying of the entire diversity of events which may exist in reality. Imagination helps the commander to see behind the signs and symbols living people, real processes and the intertwining of necessary and random ties.

The recreation of a combat situation in all its details and elements is the result of the creative thinking of a commander. Regardless of the successes of cybernetics, the problem of ensuring effective information retrieval, the selecting of data, their analysis, storage, indexing, correlation, abstracting and other transformations as well as its final formation for use by man at present has only been partially solved. This applies particularly to the military area. Certainly the very nature of armed combat contains those aspects which can be understood only on the basis of the creative thinking of man. Sometimes an insignificant fact which the computer was not programmed to display (a combat situation in terms of its properties is infinite), can provide more for an experienced commander who possesses the necessary knowledge than does the result of generalizing thousands of units of information.

The culmination point of the creative efforts of a commander is the working out of the plan for the forthcoming combat, the establishing of it, including the mathematical calculations, decision taking and the planning of forthcoming actions. The plan of the commander for combat is the result of enormous preparatory work in elucidating the combat mission and evaluating the situation. Under present-day conditions the time allocated for decision taking and elaboration has been sharply reduced. The time factor determines the possibility of both proposing different variations and analyzing them. In facilitating and accelerating the processing of data on the situation which can be subjected to quantitative interpretation, the computers are unable to handle many factors which do not have a precise mathematical expression. For this reason, the commander, in evaluating the possible variations of action, uses not only the computer data but also a mass of additional information which cannot be considered in constructing the mathematical models. All the more because on the path to modeling social processes, including the troop control processes, there still are great difficulties caused by the multiple factor and stochastic nature of these phenomena and by the complexity of their quantitative expression.

However, these limitations do not reduce the role of the precise calculations which determine the value of one or another decision variation. Certainly the proof of it (in contrast to the proposing of a hypothesis) relies on the means of formal logic and on mathematics. The commander is aided by calculating devices which make it possible not only to test out the "strength" of variations worked out by the commander, but also can to some degree themselves propose corresponding variations. In the given instance, the operation of the computer is externally reminiscent

of a creative search as the machine proposes variations. However here also the creative activity of man (programming) is shifted in time and space to the sources of the machine's operation. The programmer creates a mathematical model of combat, while the machine searches for the state of this model which best would ensure the achieving of the goal. Since the constructing of a model requires the solving of complicated creative problems, the results of automation at this and other stages are not only the condition for creativity but also its product. The accumulated creativity in the computer program appears before us in fundamentally new results now obtained without human participation. "In the same manner that in a storage battery we store electric energy, so in algorithms and programs for computers, in slide rules, graphs, tables and namograms we store mental labor so that at the required moment we obtain an instantaneous return,"[17] the Soviet researchers I. Anureyev and A. Tatarchenko have commented on this question.

The advantages of the machine--speed and accuracy of calculations--advance the limits of creativity. It becomes possible to calculate not one or two variations but ten and more. The computer does not conclude the process of searching for a creative solution. The variations of the decisions proposed by the machine on the highest level of control are not yet decisions themselves but rather their plans. They should be evaluated and supplemented by man, for a model never encompasses all the relationships and aspects of the original. "For this reason the conclusions obtained as a result of quantitative research are not a decision in the full sense of the word, but only the basis for taking a decision which is as a whole the result of the creative activities of the staffs and the will of the commander,"[18] writes V. Afanas'yev.

The commander, in reflecting on the decision variations calculated by the cybernetic machine, can supplement the model parameters by such a factor, for example, as the moral-political and psychological characteristics of the enemy troops, and particularly their command personnel; he can more precisely consider the general political situation in carrying out combat.

At present the quality of control, the degree of combat readiness of the troops, the state of their morale and other factors are best considered by using coefficients. This is just one of the measures which make it easier for the commander and his staff to select the most rational variation of actions. However the complexity of considering a large number of very fluid and indefinite factors and the limited time often necessitate the taking of not only an optimum decision but also an acceptable variation of a decision. It must not be forgotten that in a specific combat situation instances are encountered which are completely new, unique and which necessitate a creative approach on the part of the commander. While repetition in combat missions and situations serves as the basis for applying the regulations and consequently makes it possible to forma - ize the picture of forthcoming combat, the original features in combat

and an operation impose objective limits to the formalization and require creative solutions from the commander.

It would be wrong to feel that a creative decision is merely the result of the direct logical conclusions from the process empirical material. Although machines using the corresponding programs do take decisions, the latter, however, cannot be described as creative. Creativity remains the privilege of man who creates the program of computer operations. The rise of a creative idea which underlies a decision is always preceded by a certain difficulty in mental activity showing the disruption of the formological chain of speculation. In this instance help comes from the forms of mental activity, imagination and intuition which embody the specific features of creative thought. With their aid the conscience analyzes not only the actual data proposed as the premises for solving the given problem, but also all accumulated experience and all existing knowledge. A problem situation forces the memory of man to work, and to seek out additional sources of information. All these states are not inherent to a computer, the program and search limits of which have been rather precisely defined and do not permit an arbitrary playing of fantasy.

Fantasy and imagination make it possible to use rather distant analogies, hazy guesses and chance. A random factor (for example, an abrupt change in the weather) can serve as that additional influx of information which will make it possible to solve a creative problem as a whole. For this reason the researchers of creativity problems have constantly emphasized that chance does not replace a creative act, but merely contributes to its dynamicness on the basis of rather complete factual data.

The delimitation of the intuitive-heuristic and formal logical methods in solving creative problems is of great significance for correctly combining the computer and the commander's thinking in troop control.

In keeping with progress in the area of formalizing the ever new processes reflected by our conscience, certain mental operations which previously were considered creativity have lost this quality and have been turned over to cybernetic machines. Computers are constantly advancing the limit of creative thinking of a commander toward new, more complicated problems. One of them is the further development of heuristic programming, that is, the working out of qualitatively new methods for solving complex problems using computers. These models are constructed considering certain particular features of human creative thinking. In particular, it has been proposed that not all the variations for solving a problem be gone through, but rather the following of rules (heuristics) which at each stage of computer operations make it possible to reduce the number of trials leading to the proper decision. Heuristic programming provides speed and sufficient efficiency of the found decisions under the conditions of incomplete and current (variable) information and the particular complexity of the problem. The further development of heuristic programming will be evolutionary modeling which provides a certain capacity of the

programs for "self-improvement." This will make it possible to obtain the necessary data more quickly for taking a more sound and effective decision.

The need for heuristic and evolutionary programming did not arise by chance. It reflects objective difficulties standing on the path of creating a precise and complete mathematical model of modern combat. The actual process of armed combat contains an infinite number of such elements, many of which do not have definite significance for the course and outcome of it. Undoubtedly, oversimplification and idealization in creating the formalized model of combat or operation would tell negatively on the value of the obtained results. Regardless of the promise of heuristic and evolutionary programming, they are not an analogue of the leading "mechanisms" of creative thinking in man, for the method of constructing their programs (the sorting of a definite number of variations and a reduction in the number of trials) differs fundamentally from the forms of activity in human creative thought.[19]

Research on creative human thought shows its amazing capacity to find the shortest paths for solving untypical problems, and to make wide use of fantasy, distant analogies, hazy guesses, emotions and chance. The disclosure of the secrets of the creative "mechanisms" of thinking entails research on the dialectics of the conscious and subconscious, the processes of idea actualization, and the use of the truly unlimited possibilities of the human memory which includes the social experience of mankind. The intuitive and heuristic activities of the brain rely on formal logical methods of thought and include these methods in a detached form. This affirms the conclusion that human decision taking is characterized not by deterministic logic but rather by probability model logic. At the same time it is essential to bear in mind that ready-made types of mental problems are being programmed. Certainly only on the basis of detailed verbatim records of the human decision taking process is it possible to prepare heuristic definite programs for computers.

A commander in each battle or engagement must take a decision under completely new situations in which the preceding schemes of action provide little help. Here decisions are required considering the new demands of precisely the given situation. Since heuristic programming, like ordinary mathematical algorithms, does not reflect the entire completeness of the situations of armed combat, since the emotional factors of the behavior of the sides are completely alien to it, and since it is incapable of a great upsurge of mental forces and inspiration at the moment of decision taking, under present-day conditions it also has limited possibilities.

Nevertheless the value of heuristic programming in troop control is great. Using a computer it helps to determine the most suitable of all the possible decisions. However, a decision obtained on the basis of it again needs evaluation and supplementing by the creative thinking of the commander. This is the last and most important level of troop control.

One of the trends in the present stage of the development of military affairs is the strengthening of the collective principle in the work of the staffs in preparing data for decision taking. For this reason, electronic computers will play an ever greater role in the activities of the "integral commander" which control systems presently are.

Thus, the ASUV cannot replace the creative capacities of the commander, his initiative, critical thinking, developed logic and intuition, the capacity for risk, the ability to use knowledge from different areas of science and life, and so forth.

FOOTNOTES

1. See K. Shteynbukh, "Avtomat i Chelovek" [Automaton and Man], Moscow, 1967, p 226; "Chelovecheskiye Sposobnosti Mashin" [Human Abilities of Machines], Translated from the English, Moscow, 1971, p 35.

2. Of course, other grounds could be selected for establishing the group, however the proposed method, in our view, most fully meets the task of examining the particular features of military collectives in the designated aspect. Certainly with a comprehensive analysis of a military collective, it is essential to consider the sociopolitical aspect of it. For this reason, although on a certain level of abstraction we can disregard this aspect, in real military collectives it is necessarily present and in many ways is determining.

3. K. Marx and F. Engels, "Soch.," Vol 23, pp 351, 434.

4. A. Rapoport, "Strategiya i Sovest'" [Strategy and Conscience], Moscow, 1968, pp 255-256.

5. "Chelovek i EVM (Psikhologicheskiye Problemy Avtomatizatsii Upravleniya)" [Man and Computer (Psychological Problems of Control Automation)], Moscow, 1973, p 5.

6. A. T. Myslivchenko, "Chelovek kak Predmet Filosofskogo Poznaniya" [Man as the Object of Philosophical Cognition], Moscow, 1972, p 5.

7. K. Marx and F. Engels, "Soch.," Vol 20, p 102.

8. See W. Gray, "Zhivoy Mozg" [The Living Brain], Moscow, 1966, pp 226-227.

9. K. Marx and F. Engels., "Soch.," Vol 1, p 242.

10. Ibid., Vol 23, p 178.

11. See "Materialy XXIV S"yezda KPSS" [Materials of the 24th CPSU Congress], Moscow, 1971, p 83.

12. The concept of "individual scientific ideology" must not be confused with all the knowledge which an individual possesses. A scientific ideology crystallizes only the bases of this knowledge.

13. V. I. Lenin, "Poln. Sobr. Soch.," Vol 41, p 121.

14. K. Marx and F. Engels, "Soch.," Vol 46, Part I, p 386.

15. Ibid.

16. Discoursive is formal logical, reasoned and indirect cognition. Intuitive is the direct cognition of truths, the solving of a creative problem without a clearly realized chain of logical arguments.

17. I. Anuryev and A. Tatarchenko, "Primeneniye Matematicheskikh Metodov v Voyennom Dele" [The Use of Mathematical Methods in Military Affairs], p 17.

18. V. Afanas'yev, "Nauchnoye Upravleniye Obshchestvom" [Scientific Control of Society], Moscow, 1973, p 133.

19. See K. A. Slavskaya, "Mysl' v Deystvii" [Thought in Action], Moscow, 1968, pp 110-111.

CHAPTER 6: THE EFFECT OF AUTOMATING TROOP CONTROL ON THE FURTHER DEVELOPMENT OF MILITARY AFFAIRS

1. The Effect of Control Automation on the Nature of Combat and Troop Organization

One of the main patterns in the development of military affairs has been that the nature and methods of conducting combat have changed continuously in keeping with the saturating of the troops with new types of weapons and military equipment. The weapons and military equipping of the troops have had a determining influence on the methods of combat and operations and on military art as a whole. In solving the question of the influence of automation on military affairs, of exceptionally important significance are the methodological instructions of the founders of Marxism-Leninism concerning the designated problems. "...The successes of equipment, having scarcely become applicable and actually applied in military affairs, immediately--almost violently, and frequently moreover against the will of the military command--have caused changes and even revolutions in the method of conducting combat...,"[1] wrote F. Engels on this question. And this pattern in the development of military affairs was later pointed out by V. I. Lenin. "Military tactics," he noted, "depend upon the level of the military equipment, and Engels mulled over this truth and put it in the mouth of the Marxists."[2]

Having taken these statements as the basis, it is possible to establish the changes in the development of weapons which have occurred in the present stage, to ascertain their relationship to the development of automation and propose how all of this can be reflected in the combat and organization of the troops.

As was already pointed out, the present period in the development of military affairs is characterized by the appearance and rapid development of fundamentally new types of weapons and military equipment, by major improvements in all the previously known means of armed combat, by complete motorization of the troops and their intensive mechanization. Here the great achievements of scientific and technical progress lie at the basis of developing the new types of weapons and military equipment. "A scientific approach to solving all the questions of military organizational

development has become an imperative of the times,"[3] stressed Mar SU A. A. Grechko. Among the most recent achievements of the scientific and technical revolution, along with the discoveries in the area of the energy and transport base of armed combat (the appearance of nuclear weapons and missiles), one of the first places is held by the discoveries in electronics, the appearance of computers and other automation which improve the efficiency of control work.

The development of the existing weapons and the appearance of new more efficient ones are inseparably linked to the appearance and improvement of automation. For example, the appearance of missile weapons was caused by the most recent achievements not only in physics, chemistry, remote control, metallurgy, but also in radio electronics and automation. Some of the most important combat qualities of the guided antiaircraft missiles are the possibility of controlling their motion and the high strike accuracy. This has been achieved by using various automation devices making it possible at enormous speed within a fraction of a second to detect and eliminate possible errors in the controlled missile. Precisely due to the use of automation it has been possible to substantially increase the accuracy of the guided missiles. Without computers and the development of fundamentally new control systems on the basis of them the effective use of modern missile technology would be impossible.

The development of modern aviation is also most closely tied to automation. With the existing speeds of flight (up to 3,000 km per hour and more), the mental and physiological abilities of the pilot do not make it possible for him to promptly reflect all the diversity of the combat situation. For this reason for ensuring a response reaction (the detecting of the target, evaluating the situation, carrying out the actions and even taking a decision), man in aviation is aided by modern automated equipment. The use of automated control systems in aviation has led to a significant rise in the speed of the aircraft and to an increase in their range. By automating control, there has been a sharp broadening of the range of altitudes at which flights and combat have become possible. Modern aircraft equipped with dependable automated control systems are capable of ascending to an altitude of 20-25 km and more. Along with this, automation equipment makes it possible for modern aviation to operate effectively at low and maximum low altitudes.

The same close tie between weapons and automated control systems can be seen in the air defense troops. Modern antiaircraft artillery is equipped with advanced automated fire control systems which provide an opportunity of hitting airborne targets under any weather conditions both during the day and at night. The antiaircraft guided missiles are a qualitatively new means of modern air defense. The appearance and development of these weapons are also completely tied to the use of automation. Electronic calculating and other automation are used for guiding the antiaircraft missiles to the targets. Due to the use of automation, the accuracy of hitting the airborne enemy has been immeasurably increased. While in

World War II the antiaircraft artillery expended an average of 600 rounds and sometimes 1,000 rounds for each aircraft shot down, at present, due to the automation used in the antiaircraft missile complex, the enemy aircraft can be hit with just one missile.

The improvement in naval weaponry is also inseparable from the development of automation. Submarine cruises over thousands of kilometers to any point of the world's ocean have become possible due to the use of not only nuclear fuel but also new automated control equipment. The use of nuclear torpedoes and submarine-launched ballistic missiles by modern navies would have also been inconceivable without computers and other automation.

The automation of troop control has had a particularly strong influence on the development of nuclear missile weapons. The possibility of using these weapons by both belligerents can fundamentally change the situation in the course of combat. In addition to hitting troop groupings and other installations, the making of nuclear strikes can lead to enormous destruction, to the formation of large areas of fire, flooding and to the creation of extensive zones of radioactive contamination.

The situation in combat can be further complicated if the probable enemy will use other weapons of mass destruction along with nuclear weapons. Obviously in such a complex situation it would be impossible to get by without automatic equipment for troop control.

Thus, the more advanced types of weapons and military equipment require qualitatively new, predominantly automated control systems. At the same time, the introduction of the new control systems should have a reverse positive influence on improving military equipment. All of this, taken together, can lead to a change in the nature of troop combat.

The specific traits of modern combat can be: High decisiveness and maneuverability, dynamicness, rapid and abrupt changes in the situation, the uneven development of events along the front and in depth, and great spatial scope. The automation of troop control should have a determining influence on each of these traits, and this is manifested primarily through the development of weapons and military equipment.

For example, the decisiveness of combat is expressed in the aims of combat and the methods of achieving them, in the ability of the commanders to take bold decisions and to carry them out practically in the active, unstinting and energetic actions of the troops, and their desire to achieve victory by complete defeat of the enemy. In ensuring prompt responses to any changes in the situation, the automation of troop control contributes to the successful fulfillment of combat missions with the least expenditures of forces, means and time.

One of the most important qualitative indicators of the new equipment has always been its speed, that is, the speed of the processes carried out by

using it. The development of equipment has led to an increase in the speed of its operation.

The importance of speed in military affairs is difficult to overestimate. High speed is the main condition for achieving surprise and is one of the most important factors in victory. Speed makes is possible to seize the initiative, to impose one's will on the enemy, to anticipate enemy actions and to shift rapidly from one type of combat to another. Regardless of what phenomenon or action in war we would take, in any of them speed holds the primary role. For precisely this reason, both in peacetime and in wartime, there has always been a struggle for superiority in speed. A particularly great increase in speed in military affairs occurred after World War II and this has continued in the present.

The introduction of automation makes it possible to clearly trace the development of the most important trait of modern combat, a rise in its efficiency. For this reason in methodological terms, it is important to analyze those relationships in which there is speed in the occurrence of the major processes in combat and the development of troop control automation.

In using automated control systems it is possible to sharply increase the speed of the movement of troops and materiel. These speeds depend upon a number of objective factors, such as: The nature of the terrain, the degree of enemy resistance, the state of one's transport, the season, weather, and so forth. At the same time they are also determined by subjective factors, such as: By the ability of the commanders and the staffs to organize and support the movement of forces and means, and by the ability to quickly orient oneself under complicated, frequently changing conditions. Control automation in combat will make it possible to solve precisely this problem.

With the existing speed of the movement of troops, combat forces and means, man with his physical and mental abilities in many instances is unable to control them. Here the automation of control comes to his aid. This expands the limits of his abilities.

In increasing the speed of movement, the automation of troop control should thereby help to increase the maneuverability of combat and to create decisive superiority over the enemy in the necessary sectors and within a short time.

As a result of this, with the extensive use of automation, it is possible to increase the rate of advance of the troops and the speed of conducting counterstrikes and counterattacks by the second echelons and reserves. It is also possible to increase the speed of concentrating and dispersing the troops. This, in turn, can ensure the more successful carrying out of measures to provide defense against enemy weapons of mass destruction. An increase in the fluidity of combat can be largely aided by increasing the speed of the destruction and annihilation of enemy installations as

well as by the speed of preparing weapons for use and the delivery of them to the target. Before neutralizing or destroying the enemy, it must be evaluated, the means of destruction must be determined, the quantity or type of ammunition, and so forth. The automation of troop control can sharply shorten the time for carrying out such jobs.

The maneuverability of the troops in combat (an operation) also depends upon the speed of creating and crossing various types of obstacles, fortifications and barriers. These speeds represent an involved complex of various types of speeds related to the abilities of a man, the weapons and other military equipment.

Abroad it is felt that the rapid automated collecting of information on engineer works, the terrain and other conditions the computerized carrying out of calculations for mine laying and mine clearing, the crossing of other obstacles and the crossing of water barriers, as well as the use of engineer equipment reduce the time for carrying out the measures to organize or cross obstacles. This leads to an increase in the fluidity of troop combat.

Also of great importance is the speed in conducting reconnaissance. For example, the following fact shows this. According to calculations made abroad, it would take a modern reconnaissance aircraft 60 years to photograph the earth's surface. This task could be carried out by just one earth satellite lofted to a polar orbit in several days.[4] The use of automatic and automated equipment in organizing and conducting reconnaissance is one of the most promising directions.

The possibility of formalizing and programming the process of collecting and processing data on the combat situation has brought about the wide use of computers and other cybernetic devices in troop practices.

Foreign specialists feel that over the long run, by using special technical devices, without any human participation it will be possible to collect important information on nuclear strikes which have been made. Using electronic computers, data can also be processed automatically on the radiation and chemical contamination of the terrain. Here a computer can not only generalize the designated types of information, but also considering information on the meteorological situation, forecast the radioactive and chemical contamination and warn troops of the threat of exposure. It is felt that it would also be possible to automate the collecting, processing and generating of information on the position of one's troops. For this purpose in the companies and other troop organisms it would merely be a question of signing ordinary topographic surveyors with devices for transforming the data produced by them and transmitting this to the computer. Here the obtained information, again according to programs previously put into the computer, could be automatically processed and transmitted to the superior levels of command.

From the data of the foreign press, automation on an ever wider scale is being employed in radar, air and other types of reconnaissance. As a result, the time is reduced for acquiring, collecting, processing and issuing reconnaissance information, and its reliability and accuracy are increasing. In the opinion of foreign specialists, this increases the efficiency of troop combat.

In using computers and other automation equipment, an opportunity arises to more rapidly maneuver the nuclear strikes as well as the fire of conventional weapons. In the not distant past the concentration or shifting of fire over large distances entailed significant regroupings of the weapons. Under the conditions of modern warfare, as foreign specialists feel, the maneuvering of nuclear strikes and other weapons of mass destruction can be carried out virtually to any range without shifting the missile units. Here difficulties arise merely over the loss of time in taking the corresponding maneuvering decisions. Automated control systems, in the opinion of bourgeois military reviewers, make it possible to solve these problems too. An opportunity appears in a short period of time to shift the strikes to newly detected installations without moving the missile units. Under these conditions, the primary task of the troops will be the rapid penetration in depth behind the nuclear strikes for completing the defeat of the enemy and seizing important areas.

According to the announcements of the foreign press, the introduction of automated control systems has a positive impact upon the maneuvering of not only nuclear (fire) strikes, but also the troops themselves, that is, the subunits, units, formations and field forces. They will more promptly and completely utilize the results of the nuclear strikes. At the same time, the troops, in using automation, can more quickly escape from under enemy nuclear strikes. The subunits, units and formations which have suffered significant losses and have lost battleworthiness will be replaced by fresh forces in a shorter time. Great opportunities are opened up for carrying out flanking and envelopment movements.

Abroad it is assumed that the rapid and accurate depicting of the situation in using automated control systems can permit the commanders and staffs to make more efficient use of the troops in making rapid strikes against the enemy flanks and rear for the purpose of sharply altering the balance of forces in their favor in the selected sectors and areas. Due to the automation of control (along with other factors), favorable conditions are created for shifting from one type of combat to another, for increasing the effort in the course of combat (the operation), for committing second echelons and reserves, for changing the battle formations, and so forth. As a consequence of the faster and more effective response to changes in the situation, casualties and the losses of military equipment are reduced. Thus, the probability of carrying out the combat missions is increased.

At the same time, as foreign specialists feel, automated control equipment may also be used in combat by the enemy which also will gain an opportunity to more rapidly shift to decisive actions. For this reason, in using ASU

on ever greater scales, high dynamicness, flexibility and unevenness in the development of combat along the front and in depth will be characteristic. The methods and forms of troop combat will undergo substantial changes. In some sectors the subunits, units and formations will advance even more rapidly in depth; on others, active defenses will be employed; on still others the troops may be forced to even retreat. As a result of this, a focal character will more and more be inherent to combat, according to the assertion abroad. For troop combat with the extensive use of automation and more advanced weapons and military equipment, there will be characteristically: The ever more significant dispersion of the troops, the execution of bold outflanking and deep envelopment movements, rapid thrusts in the enemy flanks and rear, and the making of surprise and decisive strikes from various directions. Movements, marches, actions from a march formation, and highly dynamic and mobile forms of combat and operations will assume an ever more predominant significance.

In the opinion of bourgeois military specialists, the scale, conditions and aims of a troop maneuver will be significantly broadened. A maneuver will be employed not only to put the troops in a more advantageous situation in relation to the enemy, but also for the purposes of rapidly using the results of decisive strikes by effective weapons. This will make it possible to advance rapidly in depth, to bring ones troops from under enemy strikes, and to replace troops which have suffered losses or lost battleworthiness.

It is assumed that the use of ASU will also influence the increase in the scope of troop combat. This is determined by a number of circumstances: The automation helps to bring out more advanced and longer-range weapons, and increases the scope of the control systems themselves by introducing automatic equipment for transmitting information over long distances.

Possibly, in using more advanced weapons and full automation of troop control, combat will be carried out over more significant expanses than is presently foreseen. The zones of operations and the concentration areas of the units, formations and field forces can be broadened even more and the distance between the echelons increased.

Abroad it is felt that one of the characteristic traits of modern operations is the tendency for an increase in the depth and the pace of the conducted battles and operations. Here also one can trace a direct and immediate influence of troop control automation. Being equipped with modern weapons and advanced control systems, the troops are capable of carrying out more complex combat missions, and their actions can be carried out to a great depth and at a faster pace.

In the opinion of specialists, the use of full automation will lead to a maximum reduction in the period of preparing for combat. The reduction in the time available for collecting, processing and issuing information, for

taking decisions, for drawing them up and issuing them to executors will contribute to a further rise in the surprise of troop combat. Due to automation, the maneuvering capabilities of the troops are increased, and the time is reduced for carrying out the necessary regroupings and for working out measures related to the all-round support of combat.

Automated equipment on an ever broader scale will be used not only for collecting, storing and processing information and for making operational and tactical calculations, but also for determining the effectiveness of the strikes to be made.

These are the basic directions by which even now foreign specialists are tracing the influence of automation on troop combat. In keeping with the advancement of troop and weapons control systems, in the future the influence of automation on troop combat will become, in their opinion, even more significant. It is assumed that the ever greater saturating of the troops and staffs with equipment for automating the processes of collecting, processing and issuing information on the situation, for carrying out operational and tactical calculations and for giving the decisions made to the executors will contribute to the even greater complicating of combat. The desire to anticipate the enemy in making attacks, with the broad use of ASU, can lead to the appearance abroad of fundamentally new, even more advanced weapons of mass destruction and other examples of weapons and military equipment. A visible example is the appearance abroad of the multiple-charge nuclear ammunition capable of making aimed strikes simultaneously against several objectives due to the use of automation.

According to the information of bourgeois military specialists, the use of automation and other scientific and technical achievements will lead to a further improvement in the air defense complexes, the antiaircraft guided missiles, the launchers and various types of missiles with high accuracy. For example, powerful small-sized nuclear charges and super-small, low-power nuclear ammunition may appear, as well as types of weapons using various forms of directed energy. For example, the United States is already producing experimental missile bullets with a caliber from 1.6 to 20 mm. Here there has been the greatest spread of a 13-mm pistol rocket 38 mm long and weighing 14.8 kg.[5] In all the developed capitalist nations, ever more attention is being given to the development of missile weapons for tanks. Here the achievements of radio electronics are being used to a maximum degree. It is assumed that all the basic operations related to the control of tank missiles will be carried out automatically.

In the future, in the opinion of foreign specialists, computers and automation will be ever more widely used in the processes of collecting information on the enemy. In particular, there are plans for systems of miniature electronic devices capable of detecting weak sound waves, the shaking of the ground or changes in a magnetic field which occur inevitably with the movement of people or transport. Such "electronic scouts" equipped with radios can be secretly set by hand or dropped from the air into areas

of the probable appearance of the enemy. According to an announcement in the bourgeois press, such a reconnaissance unit of a seismic type was developed for the U.S. Army. The apologists of "electronic warfare" have raised a real furor around the designated electronic devices. A special program called "Igloo White" was approved and within this the Pentagon has improved various types of electronic sensors, delivery devices, relaying aircraft, ground computer data processing centers and special aviation, artillery and other combat subunits for effective fire resistance against the discovered enemy.[6]

According to the evidence of bourgeois military theoreticians, the achievements of bionics are being used to an ever greater degree for control purposes. Thus, the U.S. Army, by analogy with the sensory organs of living organisms, small-sized, highly sensitive and reliable attachments are being developed which provide automatic reconnaissance, as well as the formation, collection and processing of information on the combat situation. Bionics is being widely used in research on the designing of homing equipment. In the armies of the imperialist nations great hopes are being placed on this science in the area of improving weapons and military equipment control. For example, for the U.S. Air Force, a muscular-electric control system has been developed. This envisages the placing of special pressure sensors on the human body, and these would be connected to certain nerve endings. Such an automated system, in the opinion of the developers, is an unique substitute for the muscles and can be used for control.

In tactical elements, the development of radio electronic detection, control and communications devices is leading, in the opinion of American specialists, to the creation of an "automated battlefield." Many of the foreign authors, in describing the battlefield of the 1980's, imagine soldiers with jet engines on their back, wearing bullet-proof vests, moving rapidly through the air and firing pistols with atomic bullets.

One of the energetic supporters of this concept, Gen W. Westmoreland described such a picture of an "automated battlefield": "In the future on the battlefield enemy troops will be detected and fired upon almost instantaneously by systems which transmit data, evaluate reconnaissance information on the computer and automatically control firing. Since the probability of the initial strike will be close to 100 percent and detection devices will be used making it possible to constantly track the enemy, to fix resistance physically will become a less important necessity for large forces."[7]

This statement, like many other views of bourgeois authors, undoubtedly contains elements of an exaggeration of the role of a machine and automatic control systems. Bourgeois science always endeavors by any possible means to play down the role of man. In particular, it has been specially stressed that a future war will be a war of machines, a war of robots. Certainly, the development of automation will have an ever more essential influence

on weapons, military equipment and the methods of conducting troop combat and the war as a whole. In the future man with the help of computers will be capable of developing weapons which to a maximum degree will raise its efficiency.

The appearance of such weapons and their broad use in combat, in the opinion of foreign specialists, will lead to a new stage in the development of the nature of combat. Its decisiveness will be further increased and the actions themselves will become more complicated.

Under the conditions of nuclear warfare, as military specialists abroad feel, the use of modern, more advanced automatic equipment will make it possible to master even more significant speeds in all the processes of armed combat. In turn, this can lead to the even greater mobility and flexibility of troop combat generally.

According to the information of the foreign press, the automation of control has a substantial impact also on the organization of troops. The given relationship is already notable in the stage of developing the means and methods of armed combat. The appearance of new types of weapons, the growth of the fire and striking power of the troops and the changing nature and methods of conducting combat have necessitated new decisions in the organization of the troops. On the other hand, one can trace a direct and immediate influence of the automation of control on the organization of the troops. The introduction of computers and other automation has required additional organizational elements needed for their operation.

It is generally known that each new type of military equipment causes the creation of new formations. The development of automation provides an opportunity to prevent its excessive spread. Thus, if the rate of fire of artillery weapons is doubled by automation, then the required number of shells can be produced, having reduced the previous number of guns by one-half. By this it is possible to more rapidly deploy the necessary quantity of artillery and ensure the planning and execution of fire.

In contributing to an increase in the striking force of the troops, automation is one of the most important factors for improving the organizational structure of the subunits and units.

Striking power, as is known, consists of two basic components: the force of fire and the degree of "armoring" of the designated troop organism.

The possible solutions to the problem of increasing the fire power under present-day conditions include an improvement in automation and on the basis of it the achieving of a higher rate of fire and accuracy of the weapons.

Foreign specialists feel that, being one of the most important ways for increasing the maneuverability of troop combat, automation makes it possible to respond quickly to changes in the situation, in a brief period

of time to create an advantageous balance of forces on the decisive sectors, and to constantly strengthen the independence of the units and formations.

During the years of World War II, the division was the basic unit which could carry out independent missions on the battlefield. The appearance of new weapons, and in particular nuclear weapons, has led to a revision of the given view. In the armies of the capitalist states, the demand is being introduced more and more of the independence of actions of individual subunits on the battlefield. Abroad it is felt that only this can help to maintain the continuity of combat under the conditions of the disrupted centralized command of the troops.

The use of computers, it is felt abroad, raises the effectiveness of not only centralized control, but also decentralized. In this manner automation provides great independence of the subunits and units.

A decisive role in the independent actions of troop organisms is played by the possibility of having them carry out missions even in the event of the failure to receive aid from the command of the superior level. Only the presence in each troop organism of all the necessary elements for conducting independent combat can help achieve this. Control over such a large range of various elements under the involved conditions of a combat situation becomes possible only with the extensive use of automation.

As bourgeois military authors assert, control over modern troop organisms is becoming ever more complex. The time expenditures on the transmission of the necessary information do not always satisfy the highly dynamic nature of troop combat. For reducing the path of the information used in troop control, recently a tendency can be seen abroad of reducing the total number of troop levels subordinate to the commander.

According to information in the foreign press, such plans merit attention in the instance that they do not reduce the combat capabilities of the formations and units. The introduction of ASU helps to solve this complex problem. Certainly the elimination of one of the levels of command would cause a significant increase in the number of independent troop units directly under one commander. The broad use of computers and other control automation equipment will help to effectively coordinate their actions.

The automation of control processes has a positive influence on solving organizational questions related to reducing the vulnerability of troops to weapons of mass destruction. Abroad they have noted the important role of automation in increasing the capabilities of the troops for rapid dispersion and concentration, and in organizing reconnaissance of the weapons of mass destruction and the possible consequences of their use. The extensive use of computers and other automation providing for the automatic collection of all the information needed to organize protection against weapons of mass destruction can have a direct influence on the structure of the reconnaissance units and subunits.

The influence of the automation of control, it is felt abroad, can be seen also in the solving of such a problem as infantry armor. Thus, the broad introduction of armored personnel carriers in the troops requires more advanced controls. It is assumed that under conditions of heavy destruction the terrain can be altered beyond recognition, and for this reason the highly fluid combat of troops in armored personnel carriers and tanks is inconceivable without reliable equipment for ground navigation and special automated devices which ensure the correct actions of the subunits and units. As the foreign press has shown, the influence of the automation of control is particularly great on the organization of troops involved in the use of nuclear missile weapons, aviation and air defense. Here a large portion of the control processes and combat itself is being automated. As these processes are automated, the troop organisms carrying out these processes are eliminated and are replaced by new ones. In using computers and other automatic and semiautomatic devices, they carry out new functions. Here an ever greater proportional weight is taken up by radio and radar formations which provide effective use of weapons.

Abroad the automation of troop control is also having a great impact on the organization of the rear units and subunits. This leads to a reduction in the enormous supply apparatus. This reduction becomes possible by the greater systematization of rear supply, by reducing the inventories of various freight, by mechanizing a number of labor intensive jobs and so forth. Abroad it is felt that in using computers and other automation, for example, it is not necessary to draw up a large number of various registers, tables, reports and calculations on the supply services or other documents. Too narrow specialization of many rear bodies is not required. The automation of control will make it possible to consolidate many of these rear services.

The complicating of the nature of combat will place even higher demands upon indoctrination, skills, discipline, moral-psychological training and the physical conditioning of each man. The commanders should possess particularly high moral-combat qualities. Profound conviction in the rightness of Marxist-Leninist teachings, loyalty to the socialist motherland and to the cause of communism, a high feeling of responsibility for the successful execution of the combat mission, firm knowledge of the patterns of armed combat, the manuals and regulations, the ability to master new equipment and a clear understanding of the basic principles of automated control--these are the basic factors which ensure decisive actions by the commanders and the effective use by them of the forces and means of armed combat in any combat situation.

2. The Content and Style of Work of Commanders and Staff Under the Conditions of Using ASUV

The use of automated control systems influences not only the nature of combat but also the content and style of the work done by the commander and troop control bodies. Here it is essential to consider the following.

In the first place, the Leninist style of leadership based upon such main principles as party loyalty, scientificness and foresight, undoubtedly, is to be maintained and will assume even greater significance under the conditions of automating a number of the troop control processes. This is caused by the fact that the class approach in solving the question of using the armed forces as a whole and their component elements in particular increases its significance under the conditions of the presence of two opposing social systems, and depends upon the level of the ever increasing technical equipping of the troops and their control bodies.

At the same time, the principle of scientificness and foresight in ASUV acquire a theoretical, technical and organizational basis of a higher scientific level which provides for the use of the most recent achievements of the scientific and technical revolution in the processes of collecting, processing and issuing operational and tactical information.

In turn, this should predetermine a rise in the role of the scientific soundness of evaluating the elements of the situation, a rise in the possibilities of carrying out operational and tactical calculations in a shorter time and with greater accuracy, and the creation of a possibility to optimize the use of the forces and means. As a result of improving the quality of the process of working out a decision, the scientific soundness of the decisions to be made can rise.

The possibility of modeling combat using a computer and the forecasting of its course and outcome can provide a qualitatively new and truly scientific basis for prediction.

Secondly, centralization, unity of command and collectivism, in our opinion, will remain in the ASUV. Even broader opportunities will appear for realizing these forms.

Thus, centralization for the purpose of unifying efforts in using the ASUV can be carried out in a shorter time, with a smaller expenditure of resources and more effectively.

Unity of command and ASUV do not contradict each other. The ASUV is created for facilitating the work of the commander, and he controls and uses it. For this reason the role of the commander in the ASUV is not reduced but rather increased. That is, as under ordinary conditions, the commander's decision remains the basis of control. An ASU can create the conditions under which the solely responsible commander will have more time and opportunity for creative thinking by turning over to the computer a multiplicity of technical and certain logical operations. The role of the solely responsible commander can be increased also by another factor. He is given an opportunity more often than under ordinary conditions to personally elucidate the mission, to assess the situation and take decisions in a short time, using the calculation and information machine procedures solved on a computer with the output of the corresponding results.

The joint work of the commander and his staff using the ASUV also is maintained, although it alters its form somewhat. The role of the "advisers" is often turned over to the computers, particularly in the area of carrying out uncreative operations. Here the immediate assistants of the commander, in having more time, along with him can be concerned with analyzing the situation and the variations for using the forces and means, that is, they will help him in their intellectual and creative activities.

Thirdly, all the above-given methods of control can be realized in the ASUV on the basis of employing more advanced equipment making it possible for the commander and his staff officers to control subordinates with a smaller outlay of energy and time.

Computers with displays and other technical devices in principle increase the opportunity for more frequent contact with subordinates by personal talks by all officials of the control bodies headed by the commander. Consequently, with an effective influence on subordinates in the ASUV, depending upon the situation, any of the control methods or a combination of them can be applied.

Fourthly, it is essential to stress that the professional and organizational skills of many officials in the control bodies can undergo great changes with the ASUV. The process of thinking is somewhat formalized, and is disciplined on the basis of the previously prepared standard machine procedures for carrying out the calculations, for providing information and variations for using the forces and means. At the same time it is important to examine dialectically the "routinization" of evaluating the elements of the situation, the actions carried out using the computer, and not fall under their influence.

As a whole, the use of the most modern technical control devices can require changes in many professional skills related to the particular needs of dealing with the computer and processing the results obtained from it, to the new methods of obtaining and analyzing the elements of the situation, to taking a decision on the basis of a multiplicity of calculations and information obtained from the computer, the transmitting of instructions using various signal devices, the elaborating of new documents, forms, their reproduction, storage, accounting, and so forth.

These professional and organizational skills can be improved in the process of special training and then by practical work in the ASUV.

All the elementary acts of the control process, without exception, work for a solution which is not only the basis of control. Being born in the pangs of complicated psychological experiences of not only the commander but also the entire collective which prepares data for establishing the decision to be taken, it permeates all the activities of a complex dynamic system. The decision to be taken meets the needs of the greatest savings of forces with the greatest effectiveness. For this reason the processes

of the collection, processing and putting out of tactical information are viewed from the standpoint of facilitating the taking of a prompt and scientifically sound decision.

In automated systems, a majority of the information needed for decision taking and efficient troop control can be systematically accumulated, processed and stored in a computer.

For this reason, the very procedure of collecting tactical information may undergo a change. While without using automation a large portion of the working time of the staff officers is spent on securing the necessary information and plotting it on topographic maps, in automated systems the commanders and staffs can receive all important information either from special automated information sources or, depending upon the nature of the information and the control element, directly from the computer. All information can be provided directly to the work areas of the officials. The most valuable information can be provided in the form of a text using a printer. A portion of the lacking information can be obtained in the form of reference material from the computer through the data input and output devices.

In the foreign ASU, the collecting of information on the position of one's troops to a significant degree is done automatically, since this information is fed into the control system without human participation, using various navigation equipment which has been developed on a mechanical, electromechanical or electronic basis. Such equipment can have special devices for coding and transmitting the coordinates of the position directly to the superior commanders, or through the control element directly to the computer of the superior, adjacent, or when necessary, inferior control elements.

Abroad the manual data input devices supplied with the navigation equipment make it possible from the primary data sources to feed directly into the automated system all the remaining information which cannot be formulated without human participation. Such can be the information on the enemy, casualties, and so forth. Using a computer all the information on the situation is sorted, verified and consolidated (generalized) up to the level of detail which is essential for the involved officials of one or another control element (body).

The computer processed and generalized information in this system, as essential changes occur in the situation, is automatically transmitted not only directly to the work areas (extension devices) of the officials, but also to the computers of the senior chief, the staffs of adjacent and cooperating troops, and when necessary, to the subdinates. Here an automatic detailing and distribution of the information are carried out.

The possibility of storing a rather large amount of incoming information in the computer of the described system makes it possible for the officials

of the control bodies to obtain from it data on the situation, nature and direction of actions of one's own and enemy troops under certain conditions, information on the availability, losses and reserves of the rank-and-file, sergeant and officer personnel, weapons, military equipment and other types of support materiel.

Often in the foreign ASUV, the collecting of data on the situation can be carried out by the transit method, that is the information is processed for the purpose of obtaining the background for decision taking using the given specific operational and tactical infor...tion.

Thus, abroad in an automated system the basic method for obtaining situational data is the automatic generation of them through special devices or directly from the computer.

Certain foreign automation also makes it possible to assemble various types of information on a differentiated time scale, depending upon the degree of its importance or urgency. A portion of the information in an automated system can be put out by a previously determined time, and the other as the situation changes, in accord with definite standards (criteria). For example, in the course of a march, after crossing a certain line or a previously set number of kilometers; in crossing a river, in seizing the bridgehead, the erecting of crossings and bridges; on an offensive, after the taking of defensive lines, and so forth.

According to information in the foreign press, the collecting of tactical information as carried out in the ASUV using automatic and automated primary data sources, high-speed intermediate receiving and transmitting equipment, and devices for the automatic enhancing of data reliability makes it possible to reduce the time for assembling data on the situation, to increase its reliability and free a large number of officials from labor intensive technical work, in providing them time for the creative processing of the obtained information.

A dual procedure for data processing in the ASUV abroad is used. Telecode information is initially processed in the computers and then being sent to the display or printer, is studied and evaluated by officers of the troop control bodies. Information which has been received over ordinary communications channels undergoes primary processing by hand, and then is fed for .urther processing into the computers.

Since in certain foreign ASUV the most important information on the enemy nuclear weapons as well as on the state, condition and possibility of one's own weapons can be put out using extension devices directly at the work area of the commanders, when necessary the commanders can personally solve a larger portion of the questions related to combating the enemy weapons. In particular, using a computer, it is possible to determine more quickly the enemy installations to be hit, the required quantity and power of the ammunition for this, and their distribution between the

various delivery systems. Here, depending upon the set goals or the criteria corresponding to them, an opportunity is presented to examine several distribution variations and to select the optimum one.

Under the conditions of modern warfare, as foreign specialists feel, the use of automation will provide the implementing of centralized planning of nuclear strikes against the enemy, as a result of which the efficient use of nuclear missile weapons will be significantly increased.

Other machine calculation procedures in foreign systems are computer solved in an established sequence, and the results are sent to the printer of the officer who has made the request. After verifying the obtained data, the officer responsible for the solving of the machine procedure, reports them to his chief. Simultaneously the obtained information is sent automatically to the printers of officials who are interested in them.

The results of solving all the machine procedures in these systems are analyzed and are reported in a generalized form to the commander, while the most important and urgent are sent directly to the printer of the commander, the chief of the branch of forces or service.

Such an organization of the work, as the foreign press has pointed out, ensures the rapid preparation of all the calculation data. Here a larger portion of the work is prepared by the officers using the computer, and only the most important and urgent data can be obtained by the commander independently, without seeking the aid of subordinates and without spending surplus time on hearing reports.

Abroad it is felt that in determining the methods of troop operations, the results are first evaluated for the computer solution to the problem of defining the ratio of the forces and means of the sides. Then, in observing the situation on the display screen or on a map, the commander evaluates the capabilities of the enemy and his own troops. For increasing the graphicness of the display and for raising work efficiency, the situation can be presented on the screen in units. For example, first the grouping of enemy and own guns is shown, then the situation of the combined-arms units and subunits, and so forth. The situation on the screen is changed upon the instructions of the commander.

According to information from bourgeois military specialists, in determining the methods and forms of maneuvering the forces and means in the course of combat, the commander first of all uses the results of a computerized solution to the problems of forecasting the radioactive contamination of the terrain. And the calculations for the regrouping of forces should be done in several variations. For each of them the duration of the regrouping and the probable doses of radioactive irradiation of the personnel are determined. The obtained results are analyzed and the variation is selected which most fully meets the existing situation.

According to foreign data, the sequence and content of the commander's work depends upon the conditions of the situation. For example, in working out a decision to cross a water obstacle, determining the capabilities of one's own troops to cross it will be the basic element in evaluating the situation, along with studying the enemy. For this purpose, on the computer the demand for engineer forces and means is figured for supporting the crossing of the water barrier in keeping with the pace of the offensive being carried out. Then the possible duration of the ferrying of the troops is determined with the differing formation of the troops and different variations for the allocation and use of ferrying equipment. A comparison of the obtained results makes it possible to select the best method of troop operations and engineer support in crossing a water obstacle.

In preparing for a march, in the opinion of foreign specialists, the commander will be interested first of all in the quantity and quality of the routes in the allocated area as well as the maneuvering capabilities of his troops. For this the computer would first provide a machine procedure for planning the advancement of the troops.

At the same time it is assumed that in repelling counterattacks or counterstrikes the computer will be used to calculate the maneuvering capabilities of the enemy. The realization of this procedure will make it possible to determine the time of encountering the enemy and to plan the corresponding measures. When necessary, in such a situation the computer should solve the problem of the construction of field works. Moreover, the computer may also be used for accounting for the manning of the formations, units and subunits and for their material and technical supply.

Thus, in accord with materials from foreign sources, in all instances the computer is used primarily for such machine procedures which make it possible to evaluate the basic element of the situation which has a determining impact on the methods of combat at the given moment.

The use of automation in the work of the commander and staff in preparing data for decision taking, in the opinion of foreign military specialists, requires high organization and clarity in the execution of functional duties by all officials. The staff officers must know the scope and content of the calculation and reference information needed by the commander in one or another combat situation, and be able to promptly prepare the data needed by him on the computer depending upon the existing situation. It is felt that this shows the systematicness of the work of the commander and the staff, since their activities will rest on optimized working conditions and on machine procedures developed on the basis of generalizing the knowledge and experience of the best commanders, staffs, scientists and control science as a whole. For this reason the methods and content of the work done by the commanders and staff officers, in being somewhat limited by the confines of the automated system, will in fact be more precise, rhythmical, consistent and sound. Here theoretically the possibility of taking irrational, unsound decisions is excluded.

The putting out of tactical information in certain foreign ASUV includes primarily the giving of missions to subordinates. For this reason the automated system provides not only for the collecting of information and its passage from the bottom up, but also the issuing of information from the superior command levels to subordinate commanders and staffs in the form of instructions, commands, signals and informational messages. The information put out by the computers of the senior staffs is automatically received by the computers, relay devices and equipment of the subordinate control bodies which are the primary sources of the ASUV. An automatic exchange of previously stipulated data on the situation is also possible between officials within the staffs and command posts.

In such systems, over the telecode communications channels using the computers and other automation, only the most important information is transmitted and for which the feeding into the machine does not take a good deal of time and does not require cumbersome forms. These are first of all the basic combat missions for subordinate troops and signals relating to cooperation, warning, target designation and identification.

The remaining instructions such as the commander's plan, the detailing of the combat missions for subordinates, instructions on cooperation and ensuring the fulfillment of the forthcoming mission, are transmitted over the communications channels and by personal contact.

Abroad, the summoning of subordinates to the command post or the traveling of the commander to visit the troops for the purpose of giving combat missions is considered very effective. Staff officers can also be sent to the troops for the same purpose. Such a method makes it possible to give orders to the troops in a more accessible form, to clarify unclear questions on the spot and to check the understanding of the given mission by subordinates. However a visit by the commander to subordinates or the summoning of them to him is not always possible or advisable, as this can tell negatively on troop leadership as a whole. For this reason, abroad the issuing of a decision is frequently carried out orally or in a written (graphic) form using technical devices. And the commander gives the order orally using technical devices when there is insufficient time for organizing combat. In this instance he himself gives the missions only to those who are in the main sector or require an explanation of the basic idea of the mission. Staff officers give the missions to the remaining subordinates using technical control equipment. The transmitting of orders over the telecode communications channels holds one of the central places in the use of automation on the staffs, particularly in issuing orders to subordinates in the course of combat.

The transmitting of instructions to the troops in the form of written and graphic documents, according to the data in the foreign press, is also practiced in the period of preparing for combat. In using automation, this method can be widely employed also in the course of combat. In this instance, the written and graphic documents containing the decision are

issued using computers and other automation both to the subordinate troops as well as to all officials of the given control body, and to adjacent units, assigned and attached troops, and to the superior staff.

Abroad for accelerating the input of information into the computers, the filling out of the machine blanks starts immediately with the receiving of a combat mission. In the working part of the blank, they enter the address of the recipients and the dispatch time. Then, in sequence, as the data are received, their content is filled out. Here information is used accumulated in the machine as a result of solving other problems as well as that collected over the conventional communications channels. The signals for interaction, warning and identification can be worked out in the course of decision taking, and are also entered on blanks for being put into the computer. And each element of the decision in being written out on a blank is immediately fed into the electronic "memory" of the machine, and is transmitted immediately to the executors. Moreover, the previously elaborated system of data addressing makes it possible to issue the decision as a circular, that is, to all subordinates at once, as well as in sequence, to individual executors in keeping with the importance of the combat missions.

In the opinion of bourgeois military specialists, the choice of the method for transmitting the decision to subordinates depends upon the conditions of the situation and the availability of communications. In the course of combat, the missions, as a rule, will be given to subordinates in the form of brief combat orders transmitted over the telecode and conventional communications channels.

According to information in the Western press, the organization of cooperation in the ASUV is also undergoing changes. If this is carried out using extension devices of the computer, the coordinating of the basic questions is done in the process of elaborating the decision. The given coordination is based on information received automatically almost simultaneously in all the elements and for all officials at each command point.

Most frequently the clarification of the questions of interaction, both in preparations and in the course of combat, in the opinion of foreign specialists, can be carried out by brief orders fed into the computer and issued from it in a conveniently perceived form to the extension devices and with the subsequent clarification on the spot.

With a limited amount of time, when the decision is given to the troops without preliminary approval by the senior chief, the clarification of the questions of cooperation, like the giving of combat missions, is carried out in the course of decision taking. In this instance there is the sequential transmission to the troops of that information which is needed for organizing cooperation for each element of the decision. At the same time, the use of the troops is coordinated. Here the unsolved questions of cooperation are clarified with the adjacent and cooperating troops in

such a manner that by the time the decision is taken, all the basic questions of troop use have been coordinated and fixed on a map of the decision. It is felt that the automatic exchange of situational data between the various command levels makes it easier for the commander and the staff to maintain cooperation in the course of combat.

Bourgeois military specialists feel that the coordinating of the actions of subordinate troops using weapons of mass destruction under the conditions of rapid and abrupt changes in the situation should be carried out using communications equipment on the basis of computer-obtained data. The use of automation makes it possible even in this situation to go through one or two variations of the possible development of events within acceptable time, and to determine the basic questions for coordinating troop cooperation.

The procedure for maintaining cooperation in the course of combat may vary. It is felt that the commander or the chief of staff, in giving new missions over the communications equipment to each subordinate in sequence, gives instructions for coordinating his efforts with the actions of the supporting and adjacent troops.

Regardless of the procedure used, virtually the entire process of coordinating combat, in the opinion of foreign specialists, is based on the results of solving informational and computational problems using computers. In addition to the situational data which are continuously displayed on the screens, as a result of solving informational problems, the extension devices upon request can display information on the following: The composition of enemy forces in a set area; the quantity, nature and parameters of enemy installations which can be in the given area or in a certain zone; the combat capabilities of the enemy indicating the probable number of nuclear ammunition, its caliber and overall power; the composition of enemy reserves and their location on the terrain. Such data can also be obtained on one's own troops.

It is assumed that in the course of combat, difficulties will arise in coordinating the nuclear strikes with troop maneuvering. In using automation, the data needed for such coordination can be quickly obtained using electronic computers. In particular, the computers can determine the capabilities of the enemy to bring up its reserves, the demand for nuclear ammunition for destroying a counterattacking or counterstrike group and the areas most suited for carrying out this missions, proceeding from the available time and the readiness of the weapons, the capabilities of the troop to execute the maneuver and to utilize the results of the planned nuclear strike. Then, having determined the capabilities of the enemy and one's own troops to carry out a maneuver, the commander can quickly give additional missions to the troops and organize cooperation.

At the same time, as foreign specialists assume, it is essential to organize the exchange of new information with the subordinate, superior, adjacent

and cooperating staffs for the purpose of coordinating the methods of troop operations in carrying out the adjusted decision. This is aided by the presence of reliable telecode communications, display, printing and automatic data copying equipment. This makes it possible for the commander and the staff to get in touch with subordinates more frequently over the equipment and thereby provide them with practical help in correctly understanding the occurring changes in the situation, the ensuing missions, as well as the methods for carrying them out.

Abroad it is felt that in organizing cooperation under the conditions of a shortage of time, personal meetings with the commanders (representatives) of adjacent and cooperating troops can be carried out significantly less often than in the existing control system. In the course of combat and in situations of rapidly and sharply changing conditions, it is possible to be completely limited to just those data which will be sent automatically to the computer extension devices.

A most important condition for maintaining continuous cooperation is considered to be the providing of the continuous operation of the complex of new control equipment, and particularly the computer, the telecode communications equipment and the data input and output devices.

The processes of taking and drawing up a decision in an automated system may coincide in time. For this reason, the working out and drawing up of a decision using a computer, according to information from foreign specialists, represents a single logically and technically related process. Due to the use of automation, the opportunity arises of drawing up virtually all the basic combat documents by the time decision taking is over.

Here the amount of work to be done by the officers manually is significantly reduced, and the total quantity of combat documents worked out on the staffs is also lessened. Since the missions are given to the troops using the computer and are promptly fixed, this reduces the written combat orders. The orders given orally also do not need to be fixed by hand, as they are recorded using tape recorders (dictaphones).

Bourgeois military specialists are convinced that a combat order, being the basic document by which the taken decision is given to subordinates, particularly in the preparatory period, may maintain its significance under the conditions of automation. The transmission of the basic provisions of the decision over the automated equipment does not replace the combat order but merely accelerates the familiarization of the executors with its basic content. A written combat order even with a computer thus remains a most important document.

Since the basic data on the situation, the nature, directions of actions and state of one's troops and the enemy are systematically accumulated and generalized in the computer in keeping with the essential changes in the situation, in the opinion of foreign specialists, in an automated system

there is no necessity for submitting operational, reconnaissance and rear services reports in their traditional form to the superior control elements. They may contain only the conclusions and proposals, and sometimes, as an exception, unformalized requests, since the necessary final data are obtained in each control element from the computer.

Due to the fact that the most important information on the situation is collected automatically, in an automated system there is a significant reduction in the quantity of reports compiled manually and the content and forms of these reports are changed. They reflect only those data which are not transmitted by automation.

For this reason, for transmitting reports and instructions using automation, abroad new standard forms of documents are being employed for each variety of tactical information.

These forms are worked out together with the operational-tactical descriptions of the machine methods designed for computer use. The standard forms of combat reports and instructions are filled out either by the commanders themselves and the staff officers or by the technical personnel operating the automated equipment.

Abroad it is assumed that the availability at the computer complexes of large capacity storage units, high-speed printing equipment, situation display screens with microfilming devices, equipment for plotting the situation on maps and copying equipment and, finally, sound recording equipment make it possible to automate the documentation process and sharply reduce the quantity and content of the documents, that is, to reduce the time outlays on elaborating them. Here the organization and execution of supervision has certain particular features related to the use of the new technical control devices. The use of computers, automatic and automated primary data sources as well as display and documentation equipment facilitates the monitoring process, since the most important functions of this process (the monitoring of the position, state and nature of actions of subordinate troops) can be done automatically.

The information automatically received by the computer is supplemented by generalizations and conclusions from the staff officers. In this manner a general picture of the position and state of the troops is created.

Here a comparatively greater accuracy and reliability are achieved in depicting the actual situation, particularly in terms of the position of the troops, the levels of radiation contamination, the types and epicenters of the nuclear explosions and other data which are collected and transmitted automatically.

As is felt abroad, the use of automation in a number of the troop control processes makes it possible without any delay to evaluate the decisions of subordinate commanders from the standpoint of their advisability and

conformity to the existing situation. Here data are automatically received from subordinates on the selection of the direction and objectives of one's troops; on determining the forces for carrying out the set missions; clarifying the forthcoming battle order; designating the beginning and end of action; establishing the sector boundaries and the possible position of control posts. All this information, in reflecting the decisions of subordinates, is presented in a graphic form on the extension device of the superior commander, and thereby makes it possible to evaluate the decision and rapidly make the necessary corrections. However, such a method of work in no way excludes the other generally recognized and practically tested forms of supervision.

Only a person who directly observes and checks the position of the troops and their state can most correctly and completely evaluate the entire aggregate of the situation on the battlefield and provide the necessary aid to subordinates in using automation. This applies first of all to establishing the combat capability and readiness of the troops, and this is formed from a whole series of interrelated factors which in part cannot be given a mathematical expression and automated. It is a question mainly of the moral and political state of the troops, and the possibilities and capabilities of a person to act under the difficult conditions of destruction and contamination caused by the enemy's use of nuclear weapons.

For this reason, under any conditions, it is desirable to combine systematic inspection carried out using technical means with visits by officials directly in the troops.

The supervision carried out directly in the troops makes it possible to eliminate a majority of the detected shortcomings immediately on the spot. Abroad it is assumed that such a method provides an opportunity to give the necessary practical aid to subordinate commanders and staffs in organizing combat and carrying out the set missions.

Abroad the possibility of carrying out supervision using small groups of officers within a short period of time is considered to be a particular feature of organizing and carrying out inspection of the troops in using automation. Certainly many data obtained by the superior levels automatically will not require inspection.

Here the total time for the visits of staff officers to the troops will be significantly reduced. The basic purpose of these trips will consist not so much in carrying out supervision as in providing help on the spot considering the data not transmitted by the automated equipment.

It is felt that the putting out of operational and tactical information in the ASUV can change both the content and the methods of work of officials in the processes of giving missions, organizing cooperation, documentation, supervision and aid. On this level the basic advantage of the ASUV is the possibility of increasing the initiative of subordinates with

a simultaneous rise in the rigid centralization of control. This opportunity is provided by quickly transmitting commands (missions, signals and so forth) through one or two levels of command in transit. In the opinion of foreign specialists, along with a certain change in the work methods of the commanders and staffs in organizing combat and in troop leadership, in the course of combat within an automated control system a number of new tasks will appear directly related to the functioning of the mechanization and automation equipment.

First of all, the necessity arises of raising the level of the technical training of all officers engaged in planning combat and providing troop leadership. The staff officers should know the general procedure and particular features of solving individual machine programs (or their complexes) on the computers and other computer equipment. A certain portion of the officers should be able to make the corresponding corrections in the elaborated procedures designed for a computer solution. The new duties of a majority of the staff officers include the preparation of initial data and the filling out of the computer request blanks, analysis of the results of their machine solution and the reporting of them to the corresponding chiefs. The task also arises of monitoring the content of information circulating in the telecode communications channels.

Abroad it is felt that the monitoring of the content of telecode information is an important part in the work of the control bodies in all troop elements. Its purpose is to exclude the possibility of the entry of incorrect information into the computers and the feeding out of false information to the officials.

For monitoring purposes, all information received in the telecode channels from the automated data primary sources and the data manual input devices is "printed out" by the automated relay devices or electronic digital computers in those elements through which it passes in transit or is received at them.

From the materials of the foreign press, the monitoring of the content of information undergoing processing in a computer or stored in it is carried out in several directions. This is done by the automatic checking of data reliability in the course of its machine processing and by placing constraints on its feeding out to different officials in terms of its purpose, as well as on the output of dubious and unlikely information from the computer to other machines or various output and display devices.

An examination of the basic principles in the functioning of the foreign ASUV makes it possible to disclose certain common trends in changing the content of control activity as a whole. Along with the appearance of new functional duties related to the servicing of ASUV as well as the preparation of data for feeding into the computers and obtaining the results of collecting and processing the materials in the ASUV, the procedure is being improved for the work and interaction of the officials of the control bodies.

The higher the percentage of the reduction of manual labor, the more time is made available to the commander and staff officers for creative, mental activities, and for using those possibilities of thinking which are inherent to man alone. The nature of this thinking, in keeping with the increase in the technical equipping of the ASUV and the carrying out of complex machine procedures on the computer (up to modeling inclusively), becomes more and more analytical, and approaches the level of the activities of a scientist. For this reason, the fears on the question of the routinization of staff officer work are at least groundless. All the more so in that the technical work of preparing the data for putting into the computer can be turned over to personnel of the control bodies which is less prepared in operational, tactical and technical terms.

The forms of interactions of staff officers can be changed in two aspects. In the first place, there is no necessity of an excessive spending of time on various agreements, since all the officials will receive the same data on the basis of uniform criteria established in working out the complexes of computer-solved machine problems. Secondly, an opportunity can appear for a closer coordination of fundamentally new, creative concepts arising on the basis of analyzing information obtained in the ASUV.

The analysis made makes it possible to draw the following conclusions:

1. The style, methods and content of the work done by commanders and staffs in the ASUV in one instance can be altered only partially, and in another the changes can be sufficiently great and necessitate the acquiring of new practical skills.

2. The acquisition of these practical skills should be organized on a corresponding new base of scientific and technical knowledge.

3. Only a combination of a Leninist style of leadership with a firm mastery of the modern technical devices in the processes of the collection, processing and putting out of information can lead to a proper rise in the efficiency of troop control.

The degree of the interaction and reciprocal penetration of the above-given ideas depends upon many factors, including: The goals (functions) of the control system (body), the structure of the control system and the control bodies (points) comprising it, the level of the training of the personnel and the technical equipping of these bodies (points), the control cycles and processes occurring in the systems (bodies), and also upon the conditions of the situation.

The possibility of reducing the personnel in the staffs depends upon the designated factors. Here foreign experience has shown that the introduction of ASUV as a whole during the first stages increases the personnel of the bodies operating the control points and only as the level of knowledge of the staff officials constantly increases and as they acquire the skills of using the ASUV equipment does a tendency arise for a gradual reduction in the personnel of the control bodies.

A clear manifestation of the given trend depends upon the number of control elements of the ASUV. In turn, the ASUV is more effective the greater the number of control bodies it encompasses, in comprehensively solving the complex questions of controlling modern combat and operations.

As a whole the ASUV should introduce a disciplining and systematized character into the work of control bodies. The work of the commanders and staff officers becomes more systematic and approaches the optimum. One of the main merits of the ASUV is the virtually complete exclusion of arbitrariness and a superficial analysis of the situation and the taking of careless decisions. In this manner control is reliably protected against voluntarism and firm scientific bases are provided for troop leadership.

3. Criteria and Methods for Evaluating the Efficiency of Automating Troop Control

The ultimate aim of automation, like control itself in combat and an operation, consists in ensuring the fullest use of the combat and maneuvering capabilities of the troops, and the prompt execution of the set combat missions by them with the least losses in personnel, weapons and military equipment.

For solving practical problems related to the introduction of ASU into the troops, the elaborating of a theory of troop control efficiency is of very important significance. First of all it is important to correctly disclose the content of this area of knowledge, to establish the general principles for approaching an assessment of optimality in automating control, to determine the criteria and work out methods for evaluating the efficiency of ASUV considering the particular features of their functioning in combat.

The necessity of working out these questions under the conditions of the ever increasing introduction of automation is particularly felt since before ordering the new control equipment one must be certain that the expenditures on it will bring a definite gain and an improving of the control system will ensure the optimum use of the forces, means and time.

The efficiency of troop combat (combat efficiency) depends upon many factors. Among them one of the most important places is held by the political-moral state and training of the troop personnel. V. I. Lenin stressed that "an awareness of the aims and causes of a war by the masses is of enormous significance and ensures victory."[8] Under the conditions of nuclear war, if the imperialists start it, the significance of morale and the training of the troops will rise even more.

Another equally important factor is the efficiency of weapons and military equipment, the importance of which is difficult to overestimate. Certainly the nature of the operations and the methods of carrying them out depend primarily upon the state of the weapons and equipment.

The quantity and quality of the personnel, the weapons and the military equipment, as well as the perfection of their organizational forms and the procedures for carrying out combat have an exceptionally great influence on the outcome of armed combat. However, the material base of armed combat and tne organizatinal structure of the troops, while being essential, are not sufficient conditions for ensuring maximum combat efficiency. The actual efficiency of troop combat depends largely upon the able use of the available forces and means of armed combat, that is, upon the efficiency of control.

Consequently, combat efficiency (E_m) can be viewed as a function of the effectiveness of the forces and means of armed combat (E_f) considering their quantity, quality, organizational structure and employed actions and efficiency of control (E_c):

$$E_m = f(E_f \cdot E_c).$$

At the same time, the necessity of a systems approach to evaluating control efficiency in combat and an operation, and consequently, the efficiency of automating troop control is determined by a definite control system which ensures the taking of decisions and the directing of troop efforts at carrying out combat missions. In evaluating the system as a whole, it is essential to consider the efficiency of the components comprising it.

One of the most important elements in an automated control system is the forces and means of control by which a response is provided to a change in the combat and operational situation. Here of primary significance are the high moral-volitional qualities, the profound knowledge and organizing abilities of the command personnel, since man plays the central role in any system, regardless of the use of the most advanced automatic devices. An important role is also played by the automation equipment and other means of control, that is, that technical basis by which the officials solve control problems. The quality of this base determines the efficiency of the control system. If this base is insufficiently perfect, then with the present scope and nature of troop combat it is difficult and in certain instances impossible to take a rational let alone optimal decision and to promptly assign missions to executors.

Another component of the automated control system by which control is carried out is the structure of the control bodies and points. We have in mind the organizational form in which the forces and means of control are represented. By the organizational form we understand the aggregate of such indicators which characterize the following:

a) The number of elements in the system;

b) The quality of each element from the viewpoint of its capacity and ability to carry out definite functions;

c) The organizational separateness of the individual groups of elements, and this can be viewed as the presence of definite subsystems which comprise the given system;

d) The procedure of interaction between the elements and subsystems in the course of their functioning;

e) The spatial interpositioning of the elements and subsystems of the given system, including the possible connecting of one subsystem to another.[9]

A third component is the aggregate of relationships into which the control bodies and points enter in the process of troop leadership in using the means of full automation. The given aggregate of relations is manifested through the work methods, the rights and functional duties of the officials.

Each of the listed components reciprocally determines the specific features of the automated control system and its efficiency. A change in any one of them leads to a warping of the system as a whole and to a reduction in the efficiency of automated control.

Here it is essential to consider that the control system, as an aggregate of the listed components, is inseparably linked by a multiplicity of direct informational ties and feedback with the troops as the object of control or the controlled system. The given feature of a control system is as determining as the feature of its integrity. Certainly only under this condition is the very process of control ensured and the control system has a practical sense.

Considering what has been said, the concept of the efficiency of an ASUV can be formulated in the following manner. The efficiency of troop control in using automation is the compensated capacities of all the components of the automated control system to provide an optimum execution of the combat missions confronting the troops. Consequently, the efficiency of an automated control system is the degree of its adapatability to solving the problems confronting it.[10]

The correct definition of the concept of the efficiency of automated control is of fundamental significance. However, the very evaluation of efficiency depends largely upon those criteria and methods which are used as the determinants. Their choice has direct bearing on the end results of the efficiency of automation.

Considering the specific features of the troop control processes, the basic demands made on the criteria for the efficiency of automated control systems come down to the following.[11]

Each criterion should:

a) Measure effectiveness of automation in strict accord with the tasks of the ASUV;

b) Describe the quality of executing these tasks in using automation equipment and other new technical means of control;

c) Permit an evaluation of the efficiency of solving the most important task of combat;

d) Be sensitive (critical) in relation to those parameters of the automated control system, the rational or optimum significance of which must be determined;

e) Have a quantitative expression;

f) Possess small dispersion, that is, provide an opportunity to determine it with sufficient accuracy without large losses and expenditures of time;

g) Provide the most accurate evaluation of the automated system from different sides as possible;

h) Be simple and have a definite physical sense.

The total of the criteria should not complicate the task of optimizing the automated control system. At the same time their number should be sufficient for satisfying the most important demands made upon controlling the nature of modern combat.

The choosing of criteria by establishing a correlation between them and the aims of combat (an operation) undoubtedly is the most correct. However it is difficult to establish such a conformity which would characterize all aspects of the automated control system, and would make it possible to judge in detail the quality of automated troop control. For this reason, along with the general criteria which reflect the degree of the conformity of the automated control processes to the aims of combat, as a rule, a rather significant number of particular (local) criteria is used. They reflect the very physical sense of control, that is, the indicators of its conformity to those tasks which directly confront it. In other words, a definite system of efficiency criteria is used.[12]

Since the entire control process comes down to a response of man to a change in the situation by the taking (adjustment) of decisions and their carrying out, the criteria for the efficiency of automating control should not only reflect the objective process of control, but also correspond to the aims pursued by the principal in the given process.

In the process of troop control, as in any other, man endeavors to obtain a satisfactory result. Ordinarily those results which correspond to the set demands are considered satisfactory. For this reason, criteria are selected with a zone of variable limits.

In evaluating the ASUV, it is essential to solve a number of questions ahead of time. In structural terms, these can be represented in the following sequence: To what degree the given system increases the efficiency of using the forces and means of armed combat; how quickly the response of officials to a change in the situation occurs in it; how resistant is the control system to enemy strikes (particularly in using weapons of mass destruction) and what are its capabilities in creating interference against them; what is the adaptability of the system to conditions of abrupt changes in the situation; by what material expenditures is the efficiency of automated control achieved; to what degree the control system reduces losses of one's own troops with enemy surprise attacks; what is the economy from automating control in the expenditure of materiel, and so forth. All the listed and other characteristics of the system by which control is carried out in combat and an operation in utilizing automation should be brought together in three large groups:

1. Factors reflecting the tactical effect provided by the automated control system.

2. Factors characterizing the technical indicators of the system.

3. Factors indicating the economic expenditures on the system and the possibility of repaying (compensating) them.

In accord with this, it is advisable to examine the tactical, technical and economic effectiveness of automating troop control in combat and an operation.

By tactical effectiveness, one understands an aggregate of indicators characterizing in quantitative terms the capacities of the automated control system to solve the problems confronting it promptly and effectively. The determining of this helps to disclose the degree to which the automated control system conforms to the operational and tactical demands under the real conditions of a combat situation with definite technical characteristics of its basic devices and economic expenditures.

By technical efficiency, one understands the aggregate of indicators reflecting in quantitative terms the technical aspect of the automated system by which troop control is carried out. In the given instance it is a question of the technical possibilities of the automation equipment and other control devices and the working convenience of officials using this equipment under the various conditions of a combat situation. To determine the technical efficiency of automating control means to answer the question of how advanced and rational are the technical means of automating control in the automated control system (with the determined economic expenditures).

By economic effectiveness, one understands the aggregate of indicators characterizing in quantitative terms the material outlays on automating control and the possibility of compensating (repaying) them. To determine the economic efficiency of automating troop control in combat and an operation means to answer the question by what price that operational-tactical and technical effect which is produced by the designated ASU is achieved.

Since the most important aim of control in combat and an operation is to ensure the successful execution of combat missions by the troops, the operational and tactical efficiency of a system is of primary significance in evaluating the automated control system as a whole. The aggregate of criteria determining the operational and tactical efficiency of automating control is fundamental. It manifests the interrelated and reciprocally determined possibilities of the components in the automatic control system.

Since the control system must provide the best conditions for carrying out combat, the operational and technical efficiency of automating troop control must be assessed from the results of combat itself. With the given forces and means by which combat is to be carried out, the indicators used for evaluating its efficiency will be sufficiently critical also for the troop control system as a whole.

In conducting combat, it is essential ahead of time to assess the tactical efficiency of automating control of the basic weapons.

As the basic criterion of practical efficiency it is possible to use such an indicator which to a maximum degree reflects the influence of automating control on the course of troop combat. As such a criterion usually they use the caused (Q_d) or prevented (Q'_d) loss or their ratio:

$$E_{ac} = \frac{Q_d}{Q'_d} .$$

Frequently such a general criterion is used as the ratio of the damage (caused or prevented) to the total outlays on automation (C_a):

$$E_{ac} = \frac{Q_d}{C_a} \quad \text{or} \quad E_{ac} = \frac{Q'_d}{C_a} .$$

With certain limitations the given criterion is sufficiently critical, particularly when the compared automated systems differ insignificantly in terms of cost. The area of applying this criterion is ordinarily restricted to the inequality $Q_d > Q_d\text{min}$, stemming from the condition of the inadvisability of using an ineffective ASU.

It is essential to note that the constraints in any posing of the problems of evaluating the efficiency of automating control are essential just as they are in evaluating the efficiency of the operations themselves. If

there is no constraint, the problem of evaluating the tactical efficiency of automated control systems looses its practical sense, since it can be formally solved in any manner.

At the same time it is essential to consider that the practical application of the given criterion entails difficulties in determining the degree of the influence of the various forces and means on the success of armed combat as a whole. At present it is not possible to find acceptable coefficients for correlating fundamentally different elements of the battle formation and to consider all the diversity of factors in the combat and operational situation. Although in methodological terms, the finding of such coefficients is possible in principle.

Until the given problem is solved, as the general criterion for the tactical efficiency of automating troop control, it is advisable to use the capacity of the automated control system to ensure the anticipation of the enemy in using forces, that is, the probability P^c of carrying out the control problems over a certain time. This criterion makes it possible to judge to what degree the automated system ensures the solving of one of the most important problems of armed combat in the course of action, namely to anticipate the enemy in deployment, in creating a superiority in forces and means on the crucial sectors, the going over to decisive actions, and thereby thwart the enemy's plans, to force the enemy to spend time irrationally and fight under disadvantageous conditions. A quantitative value of the given criterion is determined as a function of the time spent on organizing combat by our troops (t_c) and the time dictated by the nature of combat (t_n):

$$P^c = P(t_c < t_n).$$

As the particular (local) criteria for characterizing the individual aspects of automating control, it is possible to isolate the criteria of speed, scope, continuity, stability (survivability and reliability), throughput capacity, mobility, secrecy, accuracy and flexibility in the functioning of the automated control systems.

The most important speed criterion of an automated system by which the troops are controlled is the time of one complete control cycle, that is, the duration of the response by the commanders and staffs to changes in the combat and operational situation.

An evaluation (of the speed) of an automated control system can also be made by particular indicators which influence the overall duration of a full control cycle. As such data it is advisable to use the time for the collecting, processing and putting out of information (in terms of the importance categories) needed for troop control, and the time for taking the decision and assigning and issuing the missions to executors.

In addition to information on the time of the complete control cycle, in evaluating the speed of the functioning of an automated control system, also of important significance is the consideration of data on the time for carrying out the work related to drawing up the decision and working out the documents on troop control. Considering the time expenditures on these processes, in each control element and body it is advisable to determine the overall duration of all work related to troop control. The evaluation of the automated system using the given indicator will make it possible to ascertain where the work of the control bodies is most regulating with the given control system. Finally, for ascertaining the importance of one or another control element it is also advisable to determine (in absolute amounts or in a percentage ratio) the time expenditures in each element in evaluating the overall time of a full control cycle.

By the criteria for the scope of an automated control system one understands those indicators which characterize its ability to meet the needs of control from the standpoint of the spatial extent of troop combat. An evaluation of automated systems in terms of scope criteria is essential due to the tendency for a continuous increase in the combat and maneuvering abilities of the troops and the broadening of the spatial boundaries of the combat of the field forces, formations and units. The most important indicators for the scope of an automated control system in combat are the range of transmission and the area for collecting tactical information.

Additional scope criteria can be the number of control points and the number of correspondents served by the system in each control element, the number of personnel and amount of equipment (particularly motor transport) available at each point, and the number of persons directly concerned with the questions of control and also in the service sphere.

As criteria for the continuing functioning of automated control, it is possible to use the mathematical expectations of the time of the maximum interruption in control and the minimum duration of the continuous operation of the system between two interruptions. The quantitative values of these amounts are best determined by the modeling method.

To evaluate the designated automated system for the stability criteria means to determine the frequency of its failure and the duration it remains in proper working order.

The stability of a control system is provided by its invulnerability and reliability. By invulnerability one must understand the property of the system to maintain its ability to operate under enemy action, that is, with combat damage to the automation, communications and other technical control devices as well as casualties among the personnel of the control bodies and points.[13] The reliability of the system is the aggregate of indicators characterizing its capacity to operate under the conditions of normal operations with the absence of combat losses.[14]

As the basic criterion for the stability of an automated control system, one must use the stability factor as the probability of its proper working order at any arbitrarily selected moment of time.

In addition to this, in evaluating the stability of control, it is possible to use such criteria as the probability of the prompt collection of information needed for decision taking; the probability of the prompt transmission of combat orders to the basic grouping of subordinate troops; the invulnerability of the control points.

By the criteria for the throughput capacity of an automated control system, one understand the indicators reflecting its informat: n capacities. For evaluating throughput capacity, the following can be used:

a) The coefficient for the information filling of the system as the ratio of the mathematical expectation of information collectable over a unit of time to the total quantity of data needed for troop control;

b) The data processing coefficient which characterizes that portion of the total volume of incoming information which is processed over a given segment of time;

c) The data consumption coefficient which indicates that portion of the total quantity of processed information which is issued to officials and used by them in control during combat or an operation;

d) A total indicator for throughput capacity as a function of the three above-listed coefficients.

Each of them can be used for evaluating the throughput capacity of an automated system in terms of transmission, processing and use not only for the total volume of information, but also for each type of operational and tactical infroamtion individually.

For determining the quantitative values of the throughput capacity criteria it is essential to determine the amount of information which is needed for control in modern combat in each control element and body.

By the mobility criteria of an automated system by which control is carried out in combat, abroad they understand the indicators reflecting its capacity for prompt movement.

In the opinion of bourgeois military specialists, mobility is one of the most important conditions for ensuring the stability and continuity of control. To evaluate a control system for mobility criteria means to answer the question whether the methods and rates of its movement satisfy the demands imposed by the nature of modern combat. The basic mobility criteria must be considered the ability of control points to operate while in motion and their transportability by air. Here particular attention

should be paid not only to the time of taking down, setting up and the speed of moving control points, but also their cross-country capacity, and the ability to move through various obstacles and over water barriers.

Abroad it is felt that the higher the control element, the more significance should be given in evaluating the mobility of an automated system to such a criterion as the presence of highly mobile and reliable air-ground control points. Such points are particularly essential with the massed use of nuclear weapons when large impassable areas are created and it is essential to respond rapidly to changes in the combat and operational situation.

In inferior levels, an automated control system should be based on mobile control points which do not require any expenditures for taking down and setting up. For operations in the battle formations of the troops it is essential that the transport with the automated control bodies and equipment located on them be up to the qualities of the combined-arms transport.

In the superior levels, as the basic criterion of mobility, it is possible to use the ratio (in percentage terms) of the time expenditures for moving control posts to the entire time of troop combat.

Abroad it is considered that for evaluating the mobility of automated control systems, the following can be used: The share of time during which control is carried out by the full strength of forces and means; the ratio of control time from the basic command post to all control time; the ratio of the time for setting up all control points to the time of conducting combat, and other criteria.

According to the assertion of bourgeois military specialists, in evaluating the concealment of an automated control system, two problems are examined:

a) Evaluating the concealment of the position, movement and functioning of control points;

b) Evaluating the security of operational and tactical information used for control, particularly information on the decisions of commanders and the combat missions of our troops.

For solving the first problem, as the criteria it is possible to use such indicators as the degree of radio emissivity at the control points in using automation, the accepted operating conditions of radio electronic equipment, the number of decoy control points, and so forth.

In solving the second problem, the most important criterion is the degree of concealment of the transmitted information, the quanititative values of which are determined for the control elements considering its value and the obsolescence time.

The forces and means used by the enemy for reconnoitering the ASUV are extremely diverse in terms of their physical essence. For this reason, the concealment of the automated control system should be judged according to the types of reconnaissance. Of particular significance is an evaluation of the concealment of the system from enemy radio and radar reconnaissance.

Foreign specialists feel that an evaluation of the functional accuracy of an automated control system includes the following operations:

a) Ascertaining the degree of conformity of the operational-tactical information used in control to the actual conditions of the combat and operational situation;

b) Elucidating the accuracy of solving the computational problems;

c) Establishing the optimality of the decisions taken.

As the criteria for evaluating the degree to which the information conforms to the real conditions of the situation, it is asvisable to use the indicators which reflect the accuracy of its acquisition, forming, collection, processing and putting out, as well as its age. For a generalized evaluation of the accuracy of the information, it is possible to use its total distortion factor which indicates the number of signs per error. Here the basic criteria are: The age of the information as the difference between the moment of its use and the period of a change in the situation; the obsolescence time of the information, that is, the time the information keeps its value.

The accuracy of solving computational problems can be judged through the mean square errors of those quantitative values which are produced as a result of solving them. In addition it is possible to use indicators characterizing the combat effect. These include the quantity and approximate cost of the equipment saved due to increasing the accuracy of the calculations carried out using automation. From the methodological viewpoint, an evaluation of the effectiveness of the decision is one of the stages in its preparation. The optimality of the decisions must be viewed depending upon the conditions for taking them. The criteria of the optimality of a decision have determining significance in assessing the functional accuracy of the automated control systems. Since a decision lies at the basis of control, the evaluation of automated control as a whole will depend largely upon the evaluation of its optimality. For this reason, maximum attention should be paid to working out the criteria and methods for evaluating the optimality of decisions.

By the criteria for the flexibility of the functioning of an automated control system one understand the indicators characterizing its ability to adapt its work in accord with changing conditions of control in maintaining the required level of all the remaining efficiency indicators.

In assessing the flexibility of a system, it is essential to determine its capacity to shift from certain methods of control to other ones; the shifting of control from some control points to others; the linkage with other automated systems. For example, in the NATO armies, great attention is paid to the linking of control systems of the various states which are members of this aggressive bloc.

In addition, it is advisable to consider the capacity for solving new, additional control problems, for incorporating new automated equipment and other control devices in the system, and for using new methods for solving problems.

As the basic criterion for flexibility, it is essential to use the time required for reorganizing the automated control system.

In evaluating newly developed automated systems one must not be confined to analyzing their operational and tactical efficiency in terms of the given development level of operational art and tactics. It is essential to examine how capable the system is of functioning normally with the appearance of more promising types of weapons and military equipment and new methods of armed combat.

These are the basic theoretical judgments on the methods and criteria for evaluating the operational and tactical efficiency of an automated control system.

An evaluation of technical efficiency of an automated system consists in analyzing its technical solutions, that is: determining the technical capabilities and the modernity of the automated troop control equipment.

The rationality of the control equipment depends largely upon the efficiency of the system as a whole. For this reason an evaluation of the technical efficiency of automated control systems is inseparably linked with the ascertaining of their operational and tactical efficiency. In assessing the technical capacity of automated equipment, primary attention must be given to the convenience of operating this equipment under the various conditions of its combat use.

At the same time, the evaluation of technical efficiency in many instances should be linked to an evaluation of economic efficiency. The advanced nature and rationality of technical solutions for developing control equipment in many instances must be judged considering the economic outlays on realizing these plans.

In evaluating technical efficiency of an automated control system, one must first of all analyze its design and technical indicators.

In the opinion of foreign specialists, among the most important of these are: Productivity, operational reliability and mobility of the automated

control equipment and the system as a whole, as well as the frequency, weight, temperature and other specifications of its individual elements. Moreover, the degree of standardization of the automated equipment and other control equipment is a design and technical indicator. Here primary attention is paid to the design and technical indicators of the electronic computers, and particularly their extension devices.

Along with the design and technical indicators it is also advisable to assess the technical operating indicators of an automated control system. This includes: The amount of consumed energy, consumption of fuel and lubricants, the number of operating personnel, weight, area and volume of the automated equipment and other techical devices, the component parts and elements of the system.

Finally, in evaluating the technical efficiency of automated control systems, particularly newly developed ones, it is essential to judge their future prospects and feasibility. Here attention must be paid to the newness of the proposed technical means of control, and to analyze to what degree the most recent achievements of scientific and technical progress have been used, particularly in the area of radio electronics and computers.

It is equally important to pay attention to the operational, and particularly the electromagnetic, compatability of the various blocks and elements of the system.

In addition, in evaluating the technical prospects and feasibility of newly developed automated control systems, the possibilities of developing the entire range of equipment should be correctly determined.

In addition to the criteria for tactical and technical efficiency, it is advisable, in our opinion, to use the following criteria for the economic efficiency of automated control systems.

1. The economic expenditures on the system, or the aggregate of outlays related to its development, introduction and operation.

A distinction is made between two categories of expenditures: capital and operating.

The former include all allocations on the system before it is received in the troops, as well as for subsequent modernization up to the time the system is taken out of operation. Here also are included the expenditures on scientific research and experimental designing, the preparation of the problems, programs and other measures related to the software, the training of personnel, the purchasing of automation, communications and office equipment and other means of control.

The latter include the expenditures on the entire service life of the system starting from its operation. These include the expenditures on the support of operating personnel, repair of equipment, the purchasing of operating materials, and so forth.

Thus, the total expenditures (C_{ac}) on an automated control system can be determined from the formula:

$$C_{ac} = C_d + C_i + C_e + C_o,$$

where C_d--expenditures on the development of the system and the testing of its experimental model;
C_i--expenses on introducing the system;
C_e--expenditures on operating the system in the troops;
C_o--other expenditures.

2. The direct (real) economic effect (C_{re}) is the savings directly in the sphere of control activity achieved as a result of automating troop control:

$$C_{re} = C_1 + C_2 + C_3 + C_4,$$

where C_1--reduction in expenditures for support of personnel of control and communications bodies;
C_2--reduction in expenses on collecting information on the situation, combat documents, the solving of computational problems, and so forth;
C_3--reduction in expenditures on troop support;
C_4--other types of savings.

3. The indirect (combat) economic effect (C_{ie}) is the savings in the sphere of armed combat itself as obtained from automating troop control. This is expressed by the value of the increase in the possible damage caused to the enemy, by the savings in the consumption of weapons, and a reduction in the losses of one's troops, and is determined from the formula:

$$C_{ie} = C_d + C_c + C_t,$$

where C_d--the value of the increase in the possible losses caused to the enemy;
C_c--the total savings from reducing the losses of one's own troops;
C_t--total savings in the consumption of the forces and means of armed combat;

4. The repayment time of expenditures for automating troop control compensated for by the real (T_{re}) and indirect (T_{ie}) economic effects:

$$T_{re} = \frac{C_{ac}}{C_{re}}; \quad T_{ie} = \frac{C_{ac}}{C_{\Delta c} + C_{\Delta t}}.$$

In examining the methods and criteria for evaluating the effectiveness of automating troop control, it is not enough to have merely a sound evaluation of its tactical, technical and economic efficiency. There must also be a comprehensive evaluation of the system as a whole considering all types of efficiency, that is, generalized indicators are needed on the acceptability (or inacceptability) of the evaluated system.

As the most important of such indicators it is essential to use the rationality of introducing the designated automated control system. A system is rational if the increment given by it in the operational and tactical effect with a known commensurability factor is greater or equal to the increment in the expenditures on it considering the direct and indirect economic effects.

The rationality of introducing a system is determined by the ratio:

$$\frac{E^n_{ac} - E^o_{ac}}{E^o_{ac}} = \rho \frac{C^n_{ac} - C^o_{ac} - C_{re} - C_{ie}}{C^o_{ac}},$$

where E^n_{ac}--the effectiveness of new automated control system;

E^o_{ac}--effectiveness of old control system;

ρ--commensurability factor of tactical effectiveness of system and expenditures on it.

With the failure to observe this condition, economic expenditures on developing the automated system begin to exceed the increase in the required level of the tactical efficiency of control. In this instance the system is ill advised. Consequently, it is essential to seek out ways for reducing expenditures on the automating of troop control.

The rationality of introducing newly developed automated control systems can be judged from the increment in the price of an effectively operating unit of the forces and means of armed combat.

The price of the effectively operating unit of the forces and means (P_{ef}) can be determined by the formula:

$$P_{ef} = \frac{C_{ac}}{Q_{fm} \cdot E_{ac}}.$$

The increment in price is determined by the ratio:

$$P_{ef} = \frac{C^{o}_{ac}}{Q_{fm} \cdot E^{o}_{ac}} - \frac{C^{n}_{ac}}{Q_{fm} \cdot E^{n}_{ac}} ,$$

where Q_{fm}--the number of effectively operating forces and means of armed combat.

The system can be considered rational if $P_{ef} > 0$.

In determining the rationality of introduction and the amount of the acceptable level of the increase in the cost of the new ASU, its development is ordinarily envisaged sequentially, stage by stage. Independently, they examine both the individual stages of introducing a promising control system (for example, the experimental model), as well as the system as a whole.

In evaluating individual automated control systems, it is also possible to use other criteria which reflect the specific functioning of the various elements of the system. For example, in evaluating the automation of control of radar reconnaissance equipment, one uses the expected quantity of reconnoitered enemy installations, the time for presenting data on enemy means of air attack and other installations, and the cost of the effectively operating reconnaissance equipment. The criteria for evaluating automated control of rear services can be: The probability of the prompt support of troop combat, the quantity of carryover inventories at the warehouses, the expenditures on transporting materiel and equipment in the delivery sphere, as well as the cost of keeping rear service documents, and so forth. The automated control systems for missile and artillery weapons, aviation and so forth obviously have their specific efficiency indicators. However, the general principles of the approach to evaluating efficiency and many of the examined criteria are applicable for evaluating each such system.

The problem of the efficiency of automating troop control both in theoretical and methodological terms has not yet been completely solved. The authors of this book have also not posed such an aim. The examined views on the principles, criteria and methods for evaluating the efficiency of automated control systems are merely a first approach to solving this important and complex problem.

FOOTNOTES

1. K. Marx and F. Engels, "Soch.," Vol 20, p 176.

2. V. I. Lenin, "Poln. Sobr. Soch.," Vol 13, p 374.

3. A. A. Grechko, "Na Strazhe Mira i Stroitel'stva Kommunizma" [On Guard for Peace and the Construction of Communism], p 58.

4. See I. G. Zav'yalov, "Skorost', Vremya i Prostranstvo v Sovremennoy Voyne" [Speed, Time and Space in Modern War], Moscow, 1965, p 30.

5. See KRASNAYA ZVEZDA, 21 September 1971.

6. See KRASNAYA ZVEZDA, 22 March 1972.

7. U. S. NEWS AND WORLD REPORT, 15 December 1969, p 13.

8. V. U. Lenin, "Poln. Sobr. Soch.," Vol 41, p 121.

9. See V. D. Skugarev and K. O. Dubravin, "Nauka Upravleniya i Flot" [Control Science and the Navy], Moscow, 1972, p 405.

10. See Ye. S. Venttsel', "Issledovaniye Operatsiy v Voyennom Dele" [Operations Research in Military Affairs], Moscow, 1972, p 12.

11. See Yu. V. Chuyev, "Issledovaniye Operatsiy v Voyennom Dele" [Operations Research in Military Affairs], Moscow, 1970, p 413.

12. I. Anureyev and A. Tatarchenko, "Primeneniye Matematicheskikh Metodov v Voyennom Dele," p 414.

13. See "Sistemnyye Issledovaniya" [Systems Research], Annual, Moscow, 1972, p 148.

14. See Ye. S. Venttsel', op. cit., p 148.

CONCLUSION

An analysis o the methodological problems of automating troop control makes it possible to draw a number of conclusions.

The full automation of troop control is an objective and natural process. It arose not as a result of historical chance or a specific decision, but rather is a manifestation of an objective necessity stemming, on the one hand, from the logical development of a system of the "man--equipment" type, and on the other, from the development of troop control systems which are constantly being improved in line with the complicating of combat and the necessity of ever more efficient and optimal troop control.

Troop control is being automated on a broad scientific basis. A profound and complete theoretical basis for automation has become possible as a result of the rise of cybernetics, the strong development of mathematics and such areas of it as probability theory, game theory and queueing theory. The methods of modeling and formalization have gained profound development and broad use.

Along with the natural and technical sciences, social sciences also comprise a theoretical base of automation, and they examine changes in the human and social factors in control processes under the conditions of automation. Marxism-Leninism is of enormous significance for a scientific basis of automating troop control, as this makes it possible to disclose and correctly solve a number of most complex methodological problems. Consequently, full automation of troop control is an unique function of modern science, its objectification and the materialization of scientific knowledge.

The objective necessity of the rise of the automation of troop control and the profound and complete scientific bases for its development create firm and permanent prospects for its further growth and improvement. The strengthening of the defense capability of our motherland and the entire socialist commonwealth in the future will largely be determined by the development level of the full automation of troop control.

Automation is not an end in itself. It is a means making it possible for the commander and his subordinate control bodies to flexibly and efficiently control the troops under the conditions of modern warfare, and to optimize control activities. In and of itself automation is an extremely complicated process both on the theoretical and practical level. Its rise and further development have confronted military theory and practice with a whole series of involved problems the solution to which is becoming a vitally important need.

Military theoretical knowledge is confronted with the task of more profoundly understanding the processes of troop control. It is generally known that military science has constantly studied the objective processes of control. In our times this trend is becoming an imperative. At present more precise knowledge is required on the patterns of controlling modern combat, and their precise description using mathematical logical methods and algorithms for the commander's control activities. Only on such a level of military theoretical knowledge is the automation of troop control possible.

Military practice is confronted with the problem of skillfully utilizing automation. Obviously there must be not only the corresponding changes in the thinking of the officers and generals who control the troops, but also an improvement in all control activities and the bringing of them into accord with the particular features of the operation of the ASUV.

The development of automation can give rise to notions that man will be eliminated from the sphere of troop control. In this regard bold predictions have been made on the rapid development of automatic systems which will completely perform human functions in troop control. However, the real process of automation shows the groundlessness of such predictions. The greatest effect will be achieved only when the ASUV optimally combine the broad possibilities of automatic devices with the truly inexhaustible creative possibilities of man.

The ratio between man and automatic equipment existing in the ASUV will not remain fixed. The correlation between the formalized, machine-like and unformalized, creative, truly human work will always have a concrete historical nature. The real possibilities of automation are determined by the historical limits for the development of science, technology, production and military affairs. But the potential possibilities for improving it are unforeseeable. Any formalized and algorithmized area of human mental activity can be turned over to a machine. Consequently the more profoundly the processes of war and armed combat are understood, the greater it will be possible to automate the activities of man in the area of troop control in combat. At the same time, at any stage in the development of automation, there will always exist a whole series of problems where the human brain can function significantly more successfully in solving them than can a cybernetic machine.

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In the troop control systems, man will always keep the decisive place, for taking a decision for combat cannot be reduced solely to solving a logical problem. This is a social, volitional and emotional act of enormous importance. It can be carried out only by a person who has been granted the corresponding rights as well as civil and party responsibility.

Automation, without reducing the importance of man, places increased demands on him. All spheres of military activity should undergo definite changes under the conditions of the full automation of control. This applies also to the sphere of ideological conditioning, moral-political and psychological training, the significance of which will increase. The men must be aware of their responsibility to carry out military duty, to turn a knowledge of Marxism-Leninism into communist convictions and mobilize all the individual qualities of a Soviet soldier.

The automation of troop control requires a higher general educational level of the personnel. The criteria determining the professional level of the military will change. The nature of military labor to an ever greater degree will be determined by those functions which it performs in the ASUV. The extrasystem, intrasystem and command (leadership) functions will to an ever increasing degree differentiate military labor.

Full automation of troop control, in keeping with its development, will have an effect on all spheres of military affairs. Under its influence there will be a further development in the nature of combat in the direction of its greater dynamicness. There will also be a more accurate choice of the methods of conducting combat which to the greatest degree conform to the existing balance of forces, to the terrain conditions, the season of the year as well as the meteorological conditions; the cooperation of the troops will be better organized. Under the conditions of full automation, the content and style of the work of the commanders and staffs will be significantly altered. This will be apparent in the greater soundness of the decisions taken, in the accuracy and terseness of the orders given, and in the fundamental change in the staff documents which to an ever greater degree will assume a form suitable for computerized use.

Automating troop control is a modern means for increasing the efficiency of troop operations. This places ever more rigid demands upon the efficiency of the ASUV themselves, and necessitates a careful improvement in the scientifically based system of criteria and methods for evaluating such efficiency.

Full automation of troop control is one of the important aspects in the life of the Soviet Armed Forces. Each officer to one degree or another will participate in the process of introducing ever more advanced ASUV into service. No serviceman can avoid the necessity of extending to one degree or another his knowledge of the essence and content of automating troop control. This is necessitated by the present-day level of the

development of the Soviet Army and Navy. This stems from the demands of the CPSU and the Soviet government to constantly improve the combat readiness of the Armed Forces.

END

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